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SAFETY AND FEED APPARATUS FOR STEAM BOILERS.

REGULARITY in the feeding of a boiler is, as well known, an important matter as regards the proper working of the motor supplied by it, and the perfect utilization of the fuel. To obtain such regularity, numerous automatic apparatus have been proposed; but these, although in many cases ingenious, have been nearly all abandoned, either because they were too complicated or their parts were too delicate to operate in a place where the temperature is so high.

In most shops, the care of keeping the boiler fed devolves upon the stoker, who, when the water gauge, indicator, or whistle warns him of the low state of the water, sets the feed pump or injector in operation. An automatic feed apparatus, then, sure in its operation, would prove very advan-

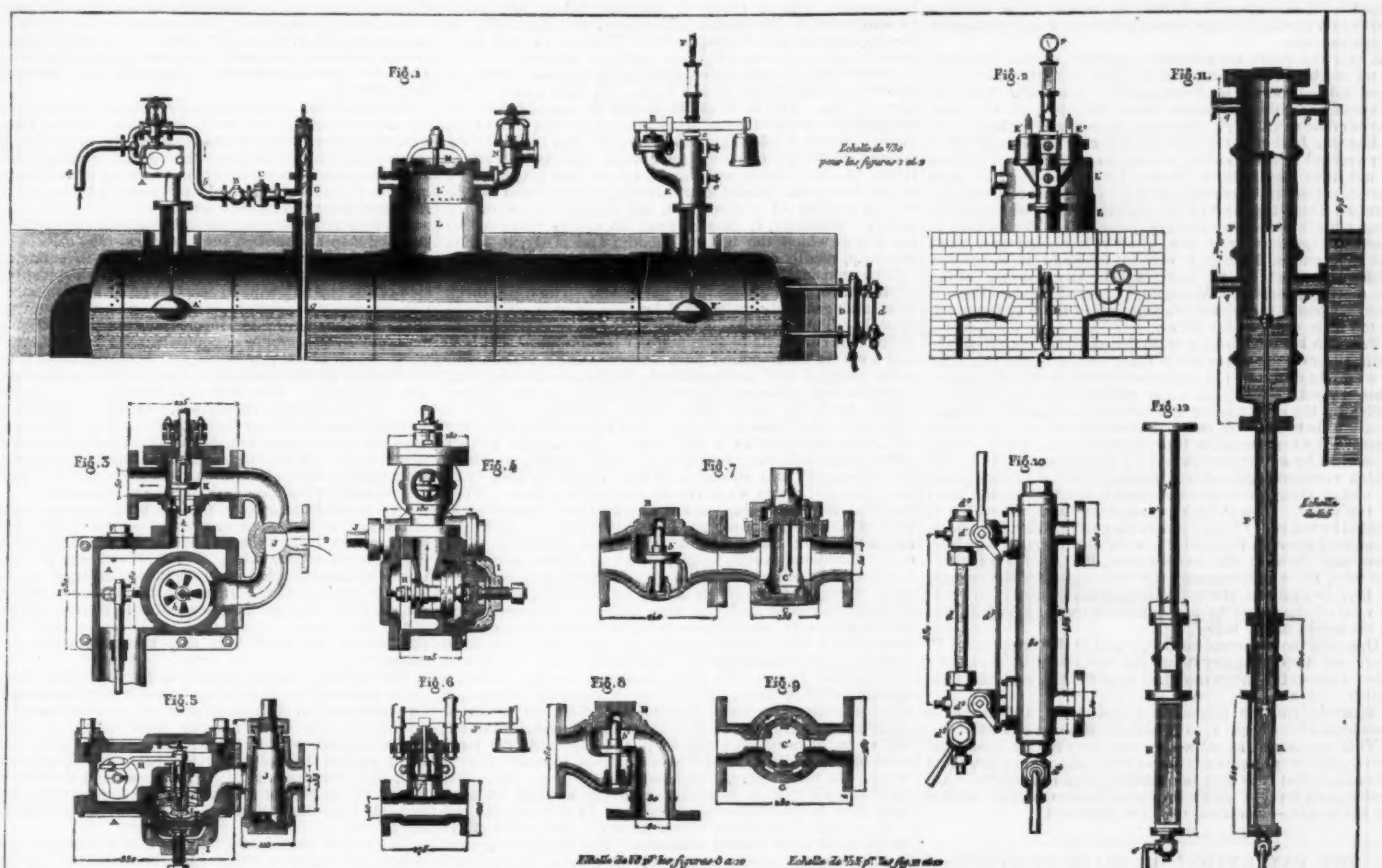


Fig. 1.—Feed Apparatus; Stop Valve; Indicator. Fig. 2.—Indicator. Figs. 3 to 6.—Regulator Figs. 7 to 9.—Check Valve and Cock. Fig. 10.– Tubular Water Gauge. Figs. 11 and 12.—Indicator.

IMPROVED SAFETY APPARATUS FOR STEAM BOILERS.

tageous as a preventive of accidents through the inattention or negligence of the stoker; but, as we have said, attempts made in this direction have not proved successful.

Messrs. Lethuillier & Pinel, of Rouen, some of whose boiler apparatus we represent in the accompanying plate, have, without stopping at the idea of having a truly automatic apparatus operating without the aid of a pump, sought to utilize the latter so as to render it dependent on the generator itself; and they have succeeded thus in constructing an automatic regulator, which, when put in communication with the water gauge of the boiler, permits water to enter or shuts it off as soon as the level falls or rises.

The feed water enters from the pump through the pipe, *a* (Fig. 1), traverses the regulator, A, and runs through the pipe, *b*, to the boiler, lifting as it does so the check valve, B. When the normal level has been reached, the float, A¹, causes a shut-off disk to operate, and the water, no longer finding a passage, goes to the hot water well, lifting as it does so a valve located on the pipe, *a*, between the pump and regulator.

The operation of the apparatus is controlled at once by the glass gauge, D, and by the magnetic indicator, E, which latter is provided with two whistles, *e* and *e*¹, that blow when there is too little or too much water in the boiler. In order to avoid having too many apertures in the boiler, the indicator is made to carry the two regulating valves, E¹ and E², as well as the pressure gauge, F. It will be remarked that the plunge-tube, *g*, that leads the feed water to the bottom of the boiler is surmounted with a cast iron cylinder, G, provided with a stuffing-box which is traversed by a rod terminating in a sort of twist drill, *g*. The object of this tool is to clean out the pipe when it becomes incrusted.

Automatic Water-level Regulator (Figs. 3 to 6).—This apparatus is shown in vertical section in Figs. 3 and 4, and in horizontal section in Fig. 5. It consists of a small iron cylinder, cast in a piece with the box, A, which contains the mechanism of the distributer controlled by the rod of the float, A¹. This mechanism includes a movable disk, *h*, mounted upon the steel axis, *h*¹, which is connected with the float rod by the lever, H. This disk contains apertures and rests against a like disk, *i*, which is cast in a piece with a bushing that is traversed by the axis and is fixed to the box by a nut. The whole is introduced through a circular aperture closed by the nut, I, the latter being provided with a plug, I¹, forming a joint and carrying a spring, *i*¹, designed for holding the movable disk, *h*, against the fixed one.

The two spaces that are to be put in communication through the movable disk, when the apertures of the latter correspond to those of the fixed disk, are connected by the three-way cock, J, and by the tubulures of the valve, K. This latter is also utilized as a check-valve, and, for this reason, the rod, *k* (Fig. 3), enters the inflated part that terminates the maneuvering screw. This screw is moved by a handwheel whose nave forms at the upper part a nut carrying a thread. When the screw is raised the valve is capable of rising; but the opposite occurs when the screw is down, because the extremity of the expanded portion rests against the valve and holds it on its seat.

The result of these arrangements is that, when the float descends, the openings in the disks come opposite to one another, and water is introduced into the boiler, following the direction of the arrows and lifting the check valve, K. When, on the contrary, the float rises, the openings come opposite the solid ports of the disk, and the water finding no longer any passage, returns through the valve situated between the feed pump and the apparatus (Fig. 6).

If, for any reason whatever, the apparatus does not operate, the interior of it may be examined and cleaned out without arresting the feeding of the boiler. To do this it is only necessary to close the check valve, K, and to turn the cock, J, by a quarter of a revolution, when the water will flow directly to the boiler without passing through the apparatus. As the axis, *h*, of the movable disk is provided with a cone that prevents the steam from passing, it is only necessary to unscrew the nut, I, in order to remove the plug, I¹, to find out what the trouble is.

Check-valves and Asbestos-packed Cocks (Figs. 7 to 9).—The system of check valve applied to steam boilers by Messrs. Lethuillier & Pinel is shown in longitudinal section in Figs. 7 and 8. The valve, *b*¹, contained in the box, B, has its central cylindrical rod guided above and below so that its upward and downward motions are perfectly true. It is formed of a simple, conical-edged disk which fits perfectly on its seat.

When the water is forced in a straight line, as in the example shown in Fig. 1, the valve box has the form shown in Fig. 7; but, if the box is to be affixed directly to the boiler, or upon a vertical cock, its flanges present themselves at a right angle, as shown in Fig. 8. In all cases it is well to place a cock between the valve and the boiler, in order that communication with the latter may be interrupted when it becomes necessary to examine the valve.

Although any cock or valve whatever may be applied here, Messrs. Lethuillier & Pinel prefer the system with asbestos packing, shown in vertical section in Fig. 7, and in horizontal in Fig. 9, and the use of which is now very common in all the industries, for distributing steam and liquids at a high temperature. In these cocks, an elastic joint made of asbestos is substituted for the friction of metallic surfaces. As may be seen, the plug, C¹, of the cock is completely cylindrical, and a certain amount of play is allowed it in the interior of the shell C, which is of corresponding form and provided with grooves into which asbestos is introduced and compressed.

The bottom of the shell is completely closed and contains a circular channel, *c*¹, filled with asbestos; and so above, the stuffing-box, which is fastened by two bolts and nuts, contains asbestos, so that the plug does not come in contact with metallic surfaces, and that there is consequently no friction except on the packing. The kind of asbestos used is that that occurs in long fibers.

Water Gauge with Asbestos-packed Cocks (Fig. 10).—A notable improvement introduced into the water-gauge by Messrs. Lethuillier & Pinel has been to mount it in a cast iron cylinder for receiving deposits of mud, and to connect the two cocks by a lever which allows them to be closed instantly at same time if the glass tube chances to get broken. It is indispensable for this that the cocks shall work freely, and for this reason the firm has applied to them the system of asbestos packing that has just been described.

Fig. 10 represents the completest type, that is to say, one consisting of a cast iron cylinder, D, provided with four tubes, the two upper of which give access to steam, and the two lower to water into the glass tube, *d*. The two asbestos-stuffed cocks, *d*¹ and *d*², are connected by the rod, *d*³, so

that by acting upon the handle of the plug of the cock, d^3, they may always both be closed at once.

The cylinder is blown off through the aperture of the cock, d^4, and the glass tube through that of the cock, d^5.

Magnetic Indicator (Fig. 2).—Omitting a description of such details of this apparatus as are well known, we may call attention to the following improvements:

1. Its present arrangement, with its cast iron cylinder, E, carrying the two safety valves, E^1 and E^2.

2. The important modification in the construction of the dial, in front of which passes a needle through the action of a magnet placed at the top of the float rod, F^1.

In former apparatus the dial plate, being silvered, soon tarnished and did not allow the figures to be seen distinctly. In the present form of the apparatus the dial is enameled, and the enamel is put on in so thin a layer that it in no wise interferes to arrest the magnetic current. As another improvement, the dial plate has, cast in a piece with it, a strengthening rib that prevents it from getting out of shape. The magnet is forked in order to allow of the passage of this rib, and the result is that, as the attraction occurs over a wider surface, the needle may be longer, and consequently more apparent.

Stop Valve (Fig. 1).—The steam dome, L, is closed by the cap, L^1, provided with manhole plate and clamp, M, and has cast in a piece with it a certain number of connecting pipes to which the firm adapt, by preference, their system of valve, N. This latter is distinguished from other similar apparatus by the following features:

1. The packing may be changed while the boiler is under pressure. To effect this, the rod is provided in the interior of the box with a small collar which, when the valve is wide open, rests against the under side of the cover. The nuts may be thus unscrewed and the stuffing-box held suspended from the nut of the hand-wheel while the stuffing is being put in, the hand-wheel nut carrying for this purpose two hooks.

2. The extent to which the valve is open may be ascertained with the greatest facility by means of a division marked on the head of the screw, this latter being graduated in centimeters.

3. All the parts are perfectly centered, so that there can be no trouble in readjusting them perfectly after they have been taken apart. By removing the bolts that hold the joints of the disk against the valve chamber, all the other pieces come apart freely, and may be replaced by hand.

Magnetic Indicator for Vertical Boilers (Figs. 11 and 12).—For vertical tubular boilers which do not admit of the use of a float in the interior, Messrs. Lethuillier & Pinel have devised an indicator consisting of a cylindrical cast iron apparatus, which is placed in front of the boiler and communicates with it by two connecting tubes. The float which is placed in the interior of this cylinder is guided by a fixed rod that passes through a central tube and is connected with the magnet which moves within the dial-case at the top of the apparatus. At the upper part of the case there is fixed a whistle for giving warning when there is too much or too little water in the boiler.

For high boilers whose installation does not permit of the indications of the water-gauge being seen at some height or at a certain distance, the apparatus shown in Fig. 11 is used. This is constructed on the same principal as the magnetic indicator, the object being to establish an apparent communication between the exterior and interior of the boiler through the very metal, without any packing. Such a result is reached by affixing to the side of the boiler a cylinder, P, which communicates with it through the two tubes, p and p^1, one of them above and the other below the normal level of the water. This cylinder contains a float, F^1, which is guided by the rod, f^1, that enters the central tube, F^1, and is connected through the rod, r^1, with the magnet, r, which rises and falls in the bronze case, R. As the length of the tube, P^1, which connects the cylinder, P, with the case, R, may be optional, the indicating apparatus may be brought in view of the stoker by proportioning the length of the rod to the height of the boiler.

Opposite the communications, p and p^1, in the cylinder, P, there are two coupling tubes for receiving the cocks of a glass tube water-gauge designed to give still another indication.

To avoid rust the magnet is nickel-plated, and its case is provided with a cock, *s*, to permit of its being cleaned.

This apparatus, as a whole, may be deemed somewhat costly, but it presents every security, and offers the great advantage that it is easy of installation and brings the indications to a level at which they may be seen at every instant by the stoker.—*Machines, Outils et Appareils.*

THE PREVENTION OF SCALE IN STEAM BOILERS.

THE formation and prevention of scale in steam boilers has been, from time to time, discussed pretty keenly in almost every mechanical and engineering journal. The number of specifics and nostrums, sold under all kinds of fancy names, for its prevention and removal, are legion. Complicated apparatus and constructions have also been proposed, and, to some extent, used for removing the scale by boiling and heating the feed-water under pressure previous to use. Unfortunately, however, the trouble and expense of these arrangements, added to their first cost, come to nearly the same thing as simply replacing the worn-out steam boiler, which has become injured by scale, with a new one. Learned articles with chemical signs and equivalents have been published, explaining scientifically the theory and formation of boiler scale; but to many steam users unacquainted with chemistry they are about as instructive as if they were written in a foreign language. Perhaps it may not, therefore, be out of place to explain, in as simple a manner as possible, the nature of boiler-scale and the cause of its formation.

What is termed boiler-scale is a mineral deposit from the feed-water, whenever hard water is used as a source of supply. All lake, river, and spring water is more or less hard. The hardness is caused by the water coming in contact with certain mineral substances, which the water dissolves to a small extent when running over or through the ground. These substances are chiefly carbonates and sulphates of lime, some magnesia, and, at times, traces of iron.

There are two kinds of hard water, which chemists call "temporary" and "permanent" hard water. The first kind, or temporary hardness, is caused by the carbonate of lime and magnesia which has been dissolved by the water, and it is called temporarily hard because when the water is boiled all the carbonate of lime is rendered insoluble, that is to say, it is no longer dissolved by the water, but is thrown out, and falls in a white, slimy deposit of carbonate of lime.

The second kind of hard water, that termed permanently hard, is caused by the sulphate of lime dissolved by the water. Simple boiling does not make it insoluble or remove it. The water therefore that contains it is permanently hard, that is to say, it cannot be softened by simple boiling, but only by boiling under a high pressure, or by heating the water up to a high temperature, which means the same thing.

All water contains more or less of these two substances, carbonate and sulphate of lime, causing the temporary and permanent hardness. They are by no means always present in the same quantities or proportions; that is to say, some waters are much harder than others, and some are much more temporarily hard than permanently hard, or the reverse may be the case.

It will be seen, therefore, from this simple explanation that the carbonate and sulphate of lime must both be rendered insoluble and deposited in the steam boiler, the first as soon as the water begins to boil, the second as soon as the water comes under the steam pressure of the boiler. It will also be evident that they will be deposited in the hottest place in the steam boiler, that is to say, just on the surface of the plates exposed to the fire, it being entirely the action of the heat that makes them insoluble. This is, of course, what takes place in practice. The coolest water in the boiler is constantly descending, the hot water ascending. The cold water is deprived of its lime salts just on the surface of the heated plate; the purified water passes up, leaving the sulphate and carbonate of lime sticking to the boiler plate in the form of scale. The action of this scale is that of a non-conductor—that is to say, it keeps the heat passing into the iron plate from being imparted to the water of the boiler; the consequence is a largely increased consumption of fuel, and the burning of the boiler plate by the fire, owing to its not being in contact with the water, and thus kept cool.

From the above simple description of the theory of the formation of boiler-scale, it will be evident that if the substances causing the hardness of the water, and also the boiler-scale, can be rendered insoluble *before* they come in contact with the heated boiler plate, the formation of the boiler-scale will be impossible. This is all that is required, and not necessarily their removal previous to entering the boiler, as they settle down to the bottom, instead of adhering to the plates or the tubes, and pass away by the blow-off tap. This is, or rather should be, the object of the many boiler compounds sold as anti-crustators; but of the many different kinds offered to the public, few fulfill the necessary conditions of doing their work cheaply and effectively. A boiler compound should, in the first place, render all the lime salts insoluble before they are rendered insoluble by coming in contact with the heated plates of the boiler. Secondly, it should have no action whatever on the iron of which the boiler is made; and lastly, it should be cheap, readily obtained, and easy to handle.

Now, considering all these points, no substance seems better suited for the purpose than pure soda. The usual form, or what is generally understood by soda, is soda ash or soda crystals. These articles, however, are not soda properly so called, but carbonate of soda more or less impure—that is to say, soda in combination with carbonic acid, and in this form sluggish and comparatively ineffective in rendering insoluble and removing the carbonates and sulphates of lime which form the boiler-scale. Soda properly so called is "caustic soda," that is to say, soda uncombined with any acid, and therefore in a free state. This article is very effective in softening water, or, in other words, rendering the carbonates and sulphates of lime insoluble, and, when *pure*, has no action whatever on the boiler plates. When required for boiler purposes it should always therefore be used in a pure state, say not less than a strength of 98 per cent., therefore the total impurities not exceeding 2 per cent. Common caustic soda, as sold in drums containing large solid blocks, does not do well for boiler purposes; the usual strength of this article is only 60 per cent., and it contains sulphur salts, besides a large quantity of common salt, which acts very prejudiciously on the boiler plates. The pure 98 per cent. caustic soda is prepared in a powdered form by some manufacturers; and one of them—the Greenbank Alkali Co., of St. Helen's—seems to have made a specialty of it in small, air-tight 10 lb. canisters, which are very convenient for small consumers. With the powdered caustic soda there is no trouble in handling or weighing out the exact quantity required, as is the case with the large solid blocks in drums, and it also dissolves instantly in cold water. In using pure, powdered caustic soda for boiler purposes, all that is necessary is to put a small quantity daily into the feed-water of the boiler. In this way the lime is al rendered insoluble, forms no scale, and passes off in the blow-off as a muddy sediment. The quantity required is quite small, as a very little really pure caustic soda goes a long way. In ordinary cases about 3 lb. added daily to the feed-water of a 20-horse boiler will keep it perfectly clean and free from scale. For large consumers, with many boilers, a more accurate estimation of the quantity required to soften the water will be necessary. It has been already mentioned that ordinary water is of varying degrees of hardness and composition, but if drawn from the same source it is generally fairly uniform. The very hardest water generally met with will be softened and the lime removed by adding one-quarter of an ounce of pure, powdered 98 per cent. caustic soda to each gallon of water. In most cases one-eighth part of an ounce is sufficient, and where the water is fairly good, one-sixteenth part of an ounce to the gallon of water will prevent all scale. To ascertain the quantity necessary, add one-sixteenth part of an ounce of 98 per cent. powdered caustic soda to a gallon of water and boil it, as this causes the lime sediment quickly to settle. Pour off the clear water and add to it another sixteenth part of an ounce of powdered caustic soda; if the water remains clear, the first addition of soda is sufficient to remove the lime salts. If it becomes muddy, the second quantity added is necessary. In this way a sufficiently accurate estimation of the quantity of pure powdered caustic soda required can be made, and then added to the feed-water in the same proportion. For example, suppose one-sixteenth part of an ounce per gallon was necessary. This will be just about four pounds of powdered 98 per cent. caustic soda to the thousand gallons; and as the cost of really pure powdered soda is about twopence per pound, the cost of perfectly softening the water will be eightpence per thousand gallons—a small cost compared with the advantage obtained of having no boiler-scale.

It may just be remarked in conclusion, that many manufacturers require soft water for several other purposes besides steam boilers. It can readily be obtained by the use of pure caustic soda, and in most cases, as with steam boilers, it is not necessary absolutely to remove the carbonate and sulphate of lime, only to render them insoluble. This is the case with all water required for washing or scouring purposes when soap is used. When the lime is once precipitated it has no action on the soap, even if it remains in the water. It is also unnecessary when required for most dyeing purposes, though, in addition to the lime, the caustic soda also removes all the iron. The removal of the sediment of carbonate and sulphate of lime and iron can of course be effected, if required, by settling out in tanks, or by passing the water through any simple form of filter bed. —*The Engineer.*

ON THE MOLECULAR RIGIDITY OF TEMPERED STEEL.*

By Professor D. E. HUGHES, F.R.S.

DURING the course of some recent researches the writer has been enabled by the aid of the induction balance to perceive some remarkable molecular differences between the constitution of iron and of steel.

There are numerous papers in the *Comptes Rendus* from 1830 to 1850 in which it is suggested that tempered steel is a true alloy of iron and carbon, the carbon being present in varying degrees according to the temperature at which the alloy was formed, and being afterward rendered permanent by sudden cooling.

In a late discussion on this subject† the writer made a few remarks, in which he pointed out the marked difference between softened and tempered steel, as to solubility in dilute sulphuric acid, and expressed the opinion, formed from these and many previous experiments, that tempered steel was a true alloy.

He has since continued these experiments, not, however, to prove the chemical composition of tempered steel, but to investigate its peculiar molecular structure, as indicated by the induction balance.

The apparatus necessary to perceive the effects of stress or torsion, as described in this paper, is exceedingly simple. Suppose, for instance, that we take an ordinary single coil electro-magnet, and join its terminals with that of a telephone or sensitive galvanometer. If we now pass a current from a battery through the iron core alone of the electro-magnet, we have a sharp click at each make and break of the current. This effect was discovered by Page, and fully described by De la Rive.‡

If we keep the current passing constantly through the core we have no effect, but if we then give a slight torsion or twist to the core either to the right or left, we at once hear a sharp click; and if we keep the torsion constant and then make frequent interruptions of the battery, we have a greatly increased sound at each make or break, indicating a greatly increased force of electric current.

In order to investigate this phenomenon, the author constructed a special though very simple apparatus.

A coil having a large aperture is fixed to a board; two small abutments or supports at a few inches distance on each side of the coil allow us to suspend or fix an iron wire passing through the aperture, which then becomes the core of an electro magnet. This forms the essential portion of the apparatus. The iron or copper wire rests upon the two supports, which are 20 centims. apart; at one of these it is firmly clamped by two binding screws, while the opposite end can turn freely. The wire is 22 centims. long, projecting two centims. beyond its support. On the projecting end is a key or arm, which serves as a pointer moving on a graduated circle, and gives the degree of torsion which the wire may receive. A binding screw allows us to fasten the wire, after turning the pointer to any degree of torsion, and thus preserves the required stress as long as is necessary.

The exterior diameter of the coil is 5½ centims., and that of the interior vacant aperture 3½ centims.; the width is two centims. Upon this coil is wound 200 meters of No. 32 silk covered copper wire. This coil is fastened to a small board, so arranged that it can be turned through any desired angle in relation to the iron wire which passes through its center; and it can also be moved so as to lie over any portion of the 20 centims. length of wire, in order that different portions of the same wire may be tested under a similar stress.

The whole of this instrument, as far as possible, should be constructed of wood, in order to avoid all disturbing inductive influences of the coil upon other pieces of metal.

The iron wire at its rear or fixed end is joined to or makes contact with a copper wire, which returns to the front part of the dial under the board and parallel to the coil, thus forming a loop. The free end of the iron wire is joined to one pole of the battery; the copper wire under the board is joined to a rheotome, and thence to the other pole of the battery.

The coil is joined to a telephone or a sensitive galvanometer; and we may either pass the current in the manner described, or may reverse all the communications, passing the current through the coil instead of the wire, and listening with the telephone to the induced currents upon the iron wire alone.

In order fully to understand the phenomena which take place, we must bear in mind Faraday's discovery of electric magnetic induction, namely, that any wire conveying an electric current induces in general a momentary secondary current in any independent circuit whose wires are parallel to it: the effect being at its maximum when two wires are parallel, diminishing as the angle of these wires is increased, and at 90° being absolutely zero. Consequently, when we place a copper wire in the axis of the coil, with the above apparatus, and pass a current through this wire, we find no effect whatever, no trace of induced currents; simply for the reason that this copper wire crosses all of the wires of the coil at an angle of 90°. We also find that no effect takes place upon torsion being applied to the copper wire. If we now place a small rod of iron parallel with the conducting copper wire, we have no effect, but if the iron rod is turned at an angle to the wires a current is observed, the force increasing from parallelism to an angle of 45°, and decreasing again from this angle to 90°, where we have again no effect. The conducting copper wire thus induces electric magnetism in the iron rod, and this magnetism reacts upon the coil; but this only holds as long as the rod is not parallel to either coil. At an angle of 90°, although at its maximum of electric magnetism, the iron rod becomes parallel to the coil upon which it reacts; consequently we have again a zero of current. In place of one rod, we may insert several short rods, and if these are all turned together in the same direction, we have similar effects.

Knowing this, we can understand that if each molecule of a rod were endowed with separate magnetic power, and if

* Paper read at the meeting of the Institution of Mechanical Engineers on Thursday, Jan. 25.

† *Proceedings* of the Institution, 1880, p. 223.

‡ De la Rive. "Treatise on Electricity," vol. i., chap. v. London, 1853.

we could cause these to rotate through any angle round the axis, we might expect similar reactions to those of the small separate iron rods already mentioned.

If we replace the copper wire spoken of by an iron wire, and send intermittent currents through it, we still have no induced current upon the coils; but the instant we apply a very slight torsion, say 10 or 20 per cent. of one turn, we at once perceive strong induced currents. These are positive for right hand torsion, and negative for left hand torsion. Thus we can not only produce induced currents, but, without changing the direction of the primary electric current, we can change the induced currents, making them positive or negative as we please; exactly as would occur if we rotated in opposite directions the small iron bars, placed side by side with the copper wire.

At this point it becomes important to know if these effects are produced by the twist given by torsion to the whole mass of the wire, or if each molecule turns separately and independently round its axis. There are many proofs that the latter view is correct. For, assuming the former, then, if an iron wire be twisted permanently by thirty or more entire turns, we should expect greatly increased effects as compared with those given by 10 or 20 per cent. of a single turn. But we find that after the first instant of torsion we have no increase of force in the current, even with a molar twist of 30 whole turns, which must of course produce a certain molecular twist; we find that the slightest torsion, say of 10 per cent. backward, is sufficient to reverse the current, and thus more than neutralize the whole inclination which had been given to the molecules by the permanent torsion. Again, if, while the iron wire is under the influence of torsion, we bring near it one pole of a large natural magnet, laid in the direction of the wire, we find that the currents gradually diminish, until when the magnet touches the wire we at last produce zero. The polarized molecules, which under the influence of torsion lay at a certain angle with the axis, have thus been caused to rotate back again, and become parallel. Again, if we approach the same pole with the magnet at right angles to the wire, we find that the current gradually returns to zero (and therefore the molecules to parallelism) when the magnet is about two inches distant; but on bringing the magnet still nearer, they pass the zero point, now giving increased reversed currents, until they reach a maximum, when the magnet is close to the wire. We have thus rotated the molecules from their original angle of torsion, say of 45° to the right, through zero to 45° to the left. If this view is correct, we should expect that we might produce electric currents of reversed directions without the aid of any battery, by simply giving a to and fro torsion to the wire; and this proves to be the case. For we may join the telephone either to the exterior coil or to the simple circuit of the wire, and we shall then hear a sharp click at each movement of torsion to the right and left; thus imitating and reproducing all the effects which would be obtained by rotating a separate magnet through different angles of inclination with the wire.

There are many proofs which confirm this view;* but as the object of the author is to show the remarkable difference which exists between iron and steel in this respect, he will confine himself to showing the very great apparent rigidity of the molecules of tempered steel as compared with those of iron.

A very remarkable difference appears when we turn to tempered steel. For here we find that at certain degrees of temper (*e. g.*, that known as blue or spring temper) there are only slight traces of molecular disturbance or rotation, no matter how many mechanical turns or twists we may put on the wire. In fact, the molecules here seem fixed and homogeneous throughout the mass. We have perfect molar elasticity, but no traces of rotation of one part over another—in other words, no molecular elasticity. Thus in iron we have an elasticity due solely to the freedom of molecular motion. In hard steel, on the contrary, we have but slight molecular freedom, with great molar elasticity, in which the separate molecules do not rotate separately, but all as one mass.

It is necessary to point out this difference of molar rigidity, as shown in tempered steel and in iron, because tempered steel is not the only form which thus differs in its mechanical and physical qualities from iron or soft steel. A similar difference is shown also by several known alloys of iron.

We can decrease the apparent rigidity of steel by the application of heat; for if we pass a constant and powerful current through the steel wire, which previously gave but feeble traces of rotation, and then heat this wire to red heat, a strong induced current is gradually produced. The current here has the power of rotating the polarized and heated molecules, and so giving out comparatively strong induced currents. But on cooling this wire it is impossible again to reduce it to silence. The molecules remain rigid, but at an angle to the axis. With iron, however, upon the application of heat under the same circumstances, we have a most violent rotation, which entirely disappears on cooling—proving again the great comparative freedom of its molecules.

We might believe that all the above effects in steel are due, not to the rotation of the molecules, but to the more or less retentive or "coercitive" force of steel with regard to permanent magnetism. But coercitive force, while it may suffice to explain, according to accepted views, the retention of magnetism, does not explain why we can produce positive and negative currents by right or left handed torsions, nor why we should have induced currents by torsion. If we accept the term coercitive force as simply applicable to each molecule, then we have still to consider the greater freedom of motion of these molecules in iron than in steel. It is a general belief (which the author has hitherto shared) that the molecules of tempered steel have far greater coercitive force than those of iron. A simple experiment will, however, prove this not to be the case. For if we suppose that the molecules of iron turn with far greater freedom, it follows that they should also turn by the application of far less force. Now, if we take a soft iron and tempered steel wire, and place them at a given distance from a suspended magnetic needle, after finding them both to be free from magnetism, and we then magnetize these wires by drawing them over the poles of a natural magnet, then we may, no doubt, find as usual that the tempered steel has a far greater amount of remaining magnetism. But if, instead of this, we limit the reactive force of the natural magnet, by placing a piece of wood, say one-half inch thick, between the magnet and the wire magnetized, thus limiting and controlling the force to any degree, according to the interval between the magnet and the wire to be magnetized, we then find, on magnetizing these two wires with a weak reactive force, and again observing its action upon the needle, that the soft iron still shows powerful retentive or coercitive force, while the tempered steel has but feeble traces of magnetism, or none at all. Thus, contrary to the author's previous convictions, it appears that *iron possesses more coercitive force than steel whenever the inducing force is limited, and within the range of iron.*

If iron merely possessed greater coercitive force than steel, it would be impossible for us to employ soft iron in electro-magnets requiring quick changes of magnetism. But although in the previous experiment the remaining magnetism was far greater in the iron than steel, yet the magnetic force of the iron, while under the influence of the permanent magnet, was some twenty times greater than its remaining magnetism; while with the steel there was but a slight difference in the force developed while it was under the feeble influence of the natural magnet, and when this was withdrawn.

Assuming the freedom of motion of the molecules to be greater in iron than steel, it occurred to the author that he should be able to free the soft iron from its remaining magnetism by simple vibration of the wire. This was found to be the case. An iron and steel wire are magnetized to saturation, or both may be given the same amount of permanent magnetism. We will suppose that they both deflect the suspended needle through 40°. Now, taking the steel wire and fastening one end in a brass vise, give its free end a slight pull to set it in vibration; it will be found that the steel has lost but 2°, having still 38° of permanent magnetism, which cannot be further reduced by repeated vibrations. The instant, however, that a similar vibration is given to the soft iron wire, its remaining magnetism nearly all disappears; there is left at most 2°, or in some cases only a trace. Thus the molecules are seen to be so comparatively free in iron that mere vibration will aid them in rotating. These two wires were again observed vibrating while under the influence of the permanent magnet. There was then a greater magnetic effect produced in the iron wire than previously; the vibrations aiding the rotations produced by the natural magnet.

The author was desirous to render visible this freedom of iron, and rigidity of steel, so that these effects might be actually seen. For this purpose we may take three glass tubes, or ordinary phials, of any length or diameter, say 10 centimeters in length by 2 centimeters in diameter. If we now put iron filings in these tubes, leaving about one-third vacant, so as to allow complete freedom in the filings when shaken, we find that each tube, when magnetized, retains an equal amount of residual magnetism, and that this all disappears upon slightly shaking the tube; we are thus imitating the effects of vibration. But if in one of these tubes we pour melted resin (or in fact any slightly viscous liquid, such as petroleum, suffices) we then render these filings more rigid, and then we can no longer produce by shaking the disappearance of its residual magnetism. In pouring in petroleum we have apparently been introducing a strong coercitive force; but we know that it can only have the mechanical effect of rendering the iron filings less free to turn, and so comparatively rigid. If we desire to see the effect of torsion, we have only to shake the filings so that when the tube is held horizontal the vacant space is above, and rotate slightly (but without shaking) the tube containing the free filings about a horizontal axis. Its remaining magnetism instantly disappears upon rotation, although we evidently have not changed the longitudinal position of its particles. A similar effect takes place upon a soft iron wire, for if we magnetize it and observe its remaining magnetism, we find that upon giving a slight torsion to this wire, its remaining magnetism instantly disappears—a similar effect to that in the rotating tube of iron filings.

The author has remarked in these researches that in all alloys of iron the molecules are far more rigid than in the pure metal; and further that, with steel, tempering adds greatly to this rigidity. He is now engaged upon the question of the effect of different tempers on the same steel, and hopes in a future paper to be able to bring the results before the Institution.

Soft steel, when compared with hard drawn iron, shows that the mechanical hardening of iron has not in any great degree diminished its molecular freedom. Even the softest steel shows a high degree of molecular rigidity, as compared with the hardest iron, but far less than that of tempered steel. This would seem to indicate that steel in its softest state is still an alloy, though only feeble quantities of carbon may be held in that condition.

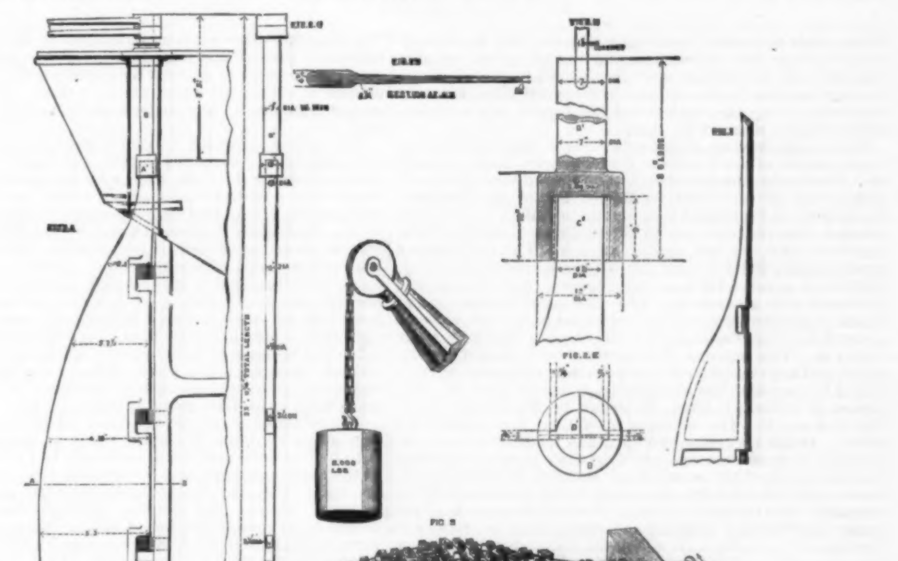
We thus perceive that a great physical change takes place in iron upon the slightest alloy with carbon; and that tempering produces this change in its highest degree. The writer, therefore, is strongly in favor of the view propounded long since, that steel when tempered is an alloy, containing fixed carbon in a far greater quantity than when soft. We know the physical properties of magnetic oxide of iron, of iron and tungsten, and of iron and sulphur. Now, in all these the writer has found that the iron loses its molecular freedom when even slightly alloyed. The physical results are, therefore, the same as those produced in tempering steel; and the induction balance thus indicates strongly that tempered steel shows the characteristics of a true alloy.

We could not have such a great physical difference between iron and steel, as above noticed, except by corresponding changes in its mechanical properties; and it is with a view of bringing out these relations in a discussion on this point that the author has ventured to bring his views before the Institution of Mechanical Engineers.

* "Molecular Magnetism," by Professor D. E. Hughes, *Proceedings of the Royal Society*, March 7-17, and May 10, 1881.

CRUCIBLE CAST STEEL STERN FRAMES AND RUDDERS.

THE notion of producing stern frames and rudders for ships in steel castings, as far as we at present know, originated with Mr. J. F. Hall, manager to Messrs. Jessop, who several years ago conceived the idea in revising the designs of a small steam yacht, at the request of a friend, for whose private use it was eventually destined, and who wished to have as much of it in steel as possible. Shortly after this, during the winter of 1880-81, he brought the subject under the notice of a launch and boat builder in Hull, who leased a small yard from Messrs. Bailey and Leetham, shipowners, of that place. This gentleman placed an order with Mr. Hall's firm for two small stern frames and rudders for steam pinnaces he then was about to build. The first of these



CRUCIBLE CAST STEEL RUDDER FOR THE S.S. LA PLATA.

was only delivered and put into the vessel when the subject was brought under the notice of Mr. Thomas Thompson, engineer to Messrs. Bailey and Leetham, who from that day, to use his own words, "made up his mind that the new feature was a correct one, and that he would adopt it on the first feasible occasion on a much larger scale." This opportunity, however, did not occur till a few months ago, when a very serious mishap, nearly resulting in the total loss of one of his employers' ships—the La Plata—through breaking her rudder, as shown in Fig. 1, during a storm in the North Sea, again brought to his mind the often-repeated solicitations of Messrs. Jessop's representative to have his rudders, as well as his stern frames and propellers, in crucible steel castings. Obtaining the consent of his employers, he placed an order with Messrs. Jessop for a crucible cast steel rudder, to replace the one made on the old lines, and which had so nearly caused the loss of the vessel herself. A few matters of detail on the subject of strengths, about which Mr. Thompson as yet was, of course, somewhat in doubt, were dispelled by the positive assurances of Mr. Hall, who guaranteed to produce a stronger rudder than had yet been put into any of the ships under his supervision. The next consideration, however, was as to how the change would be accepted by the Underwriters' Registry for Iron Vessels, with whom the ship was classed. Communication was therefore opened with the committee of that body, who at once gave their consent, and agreed to accept the solid crucible cast-steel rudder, as designed by Mr. Thompson, and shown in detail by Figs. 2, 2 A, B, C, D, and E, provided it stood certain tests to be carried out under the supervision of their Hull surveyor. These tests having been accepted by Messrs. Jessop, the rudder was at once put in hand, and a few weeks later, on the 15th of September last, it was successfully cast by Mr. J. Banham, the superintendent steel melter of the firm. About the middle of the casting operation two sample test bars were taken from the metal flowing into the mould, and being carefully sealed and marked by the surveyor, were left to cool and anneal along with the rudder for future manipulations. Subsequently, when the rudder casting had been cleaned and dressed, it was subjected to the following severe tests:

First, the rudder was laid horizontally, with its ends resting on supports, and the blade at first propped up by a post, which, as the balance came on, fell away—see engraving, Fig. 3. The rudder blade was loaded with an evenly distributed weight equal to a total of 12,300 lb., and balanced by a weight of 2,240 lb. at the end of a lever 12 ft. long, securely fastened on the rudder head, which was 6½ in. diameter. The effect of the lever itself was 3,920 foot-pounds, weighing, as it did, 784 lb., with an effective length of 5 ft. The rudder head therefore sustained a torsional strain of $(2{,}240 \times 12) + (784 \times 5) = 30\,800$ foot-pounds. The center of loaded surface of the rudder was 2 ft. 6 in. from the center of the rudder head, and the area of the blade was 86 square feet, so that the weight per square foot of rudder area, including weight of rudder, was $\frac{30{,}800}{2 \cdot 5 \times 86} = 143$ lb. While under this torsional strain a 2,000 lb. weight was dropped from a height of 4 ft., striking the rudder at the center of the area of blade, and in neither case was there any sign of a twisting movement in the rudder head. The rudder was then lifted to a height of 9 ft. 3 in., and dropped on to the foundry hard floor without the slightest fracture. Being again suspended and struck all over with hand hammers, it rang like a bell from end to end. The bars that had been cast for testing were then placed in the machine; but they were in the rough, and had several slight flaws on the edges. Two other bars of the best forged iron were also selected to test along with them.

These tests having considerably more than satisfied the requirements of the Liverpool Underwriters' Registry, and Mr. Thompson himself being well pleased with them, the rudder was delivered over to Messrs. Bailey and Leetham, on the 30th of September last, and in less than a week was shipped into its place on the stern frame of the La Plata, which at once set sail on her voyage. The La Plata is a screw steamer 298·3 ft long, 32·1 ft. beam, and 21·5 ft. deep, 1,778 tons gross, 1,152 tons net register, with top-gallant forecastle and short poop. The cast steel rudder head or shank is not carried up to the top of the poop, but stops off about 8 ft. above the counter of the ship, as shown at A[1], in Fig. 2 A. The top end of the rudder head is cast slightly taper, and has two projections or feathers cast on—see D[1] in Fig. 2 E—to which the wrought iron rudder head, B[1], with socket at bottom, is fitted, as shown by B[1], C[1], and D[1], in Fig. 2 D and E. The advantages of this arrangement are many. In the first place there is a less tendency of the rudder head to twist or warp in cooling after casting, and there is also less risk of the rudder head, through its otherwise extreme length from point of casting, being honeycombed or unsound. But the chief advantages after all are perhaps the better facilities for shipping and unshipping the rudder in dry dock or on a slip way, where the usual drop is not more than from 4 ft. to 5 ft. from keel to dock bottom; whereas in a full pooped ship from 9 ft. to 10 ft. would be required, thus necessitating the ship being floated for shipping or unshipping the rudder. The La Plata has now had three months' good work with her steel rudder, and passed through some exceptionally rough weather, having made the following voyages: From Hull to Cronstadt, from Cronstadt to Hull, from Hull to Cronstadt, from Cronstadt to London, from London to Shields, and at the present time she is on her way from Shields to Alexandria. The report of the captain is that the rudder works and answers admirably.—*The Engineer.*

SWING BRIDGE AT HAMBURG.

In several of the recent numbers of our valuable contemporary, the *Zeitschrift des Vereins Deutscher Ingenieure*, there have appeared engravings and descriptions of a swing bridge at Hamburg, of which we now give a diagram with the following description, as translated by *Engineering*.

The bridge in question is situated over a narrow and short canal, the Niederbaum Canal, connecting the Nieder harbor with the dock; and since a very large traffic takes place both over and through the bridge, mechanical appliances for rapidly opening and closing the latter had to be provided. The available space near the abutments of the bridge being extremely limited, and not admitting of the employment of steam power with or without hydraulic accumulators, it was decided to utilize the water pressure from the town water supply, amounting only to from 35 lb. to 38 lb. per square inch.

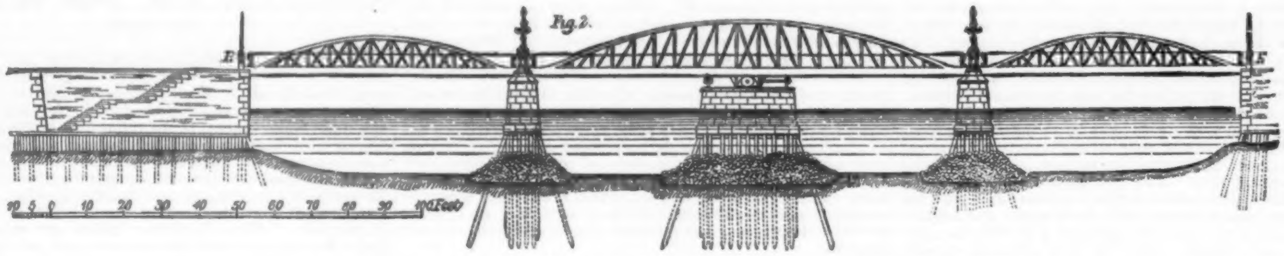
The bridge, of which a general elevation is shown, was built during the years 1878 to 1880. It consists of two fixed spans adjoining the bank, each with an opening of 72 feet 6 inches, and a central double armed swing span of 118 feet total length, giving two clear openings of 49 feet 3½ inches each. Each span consists of a pair of parabolic bowstring girders, placed at 23 feet 10 inch centers, and connected at intervals of 5 feet 7 inches by cross girders; a roadway of 20 feet 8 inches clear is thus formed, paved with asphalt on concrete, the latter resting on inverted arched plates supported by the cross girders. Outside the main girders on each side, footpaths nearly 6 feet wide are carried on brackets. The bridge was designed with a view of putting down rails and carrying heavy goods traffic over it by means of locomotives, and it was partly for this reason that the footway was placed outside the main girders.

The principal conditions specified for the construction of this bridge were, that the bridge could be opened and closed both by hydraulic and, when necessary, by hand power; that in the former case the time for opening and closing should be under five, and in the latter, with two men, under ten minutes. It was also deemed advisable that the bridge should be worked by turning it through an angle of 180 degrees rather than through 90 degrees, and turning back. All mechanism required for the working of the bridge was to be placed and concealed within the central pier.

The only acceptable tender fulfilling these conditions was that from Mr. Vollbering, of Sudenberg, near Magdeburg, and with few alterations, found necessary by the town authorities, his design was accepted in July, 1878.

The total weight of the fully loaded bridge, about 607 tons, is distributed so that each end takes 50 tons, and the center 507 tons. The structure of the bridge alone weighs 299 tons, 28 tons of which are supported at each end, and 187 tons at the center.

To perform the various operations of turning and resting the swing span on its bearings, both hydraulic and hand power gear are provided; the former consists of two hydraulic water motors, with oscillating cylinders, constructed by Mr. A. Schmidt, of Zurich. They have cylinders 6¼ inches in diameter, with 7¾ inches stroke, and when running at ninety revolutions work the bridge of 299 tons at the rate of 2 feet 3½ inches per second. The motors are coupled to a crankshaft, the cranks being set at right angles, and from this crankshaft all the various motions required are derived by means of gearing. It being conditional to be able to work the bridge in both directions, a special intermediate cylinder fitted with a piston is provided to reverse the current of the water. The hand-turning gear for the bridge is entirely independent of the hydraulic gear.



SWING BRIDGE AT THE NIEDERBAUM DOCK, HAMBURG.

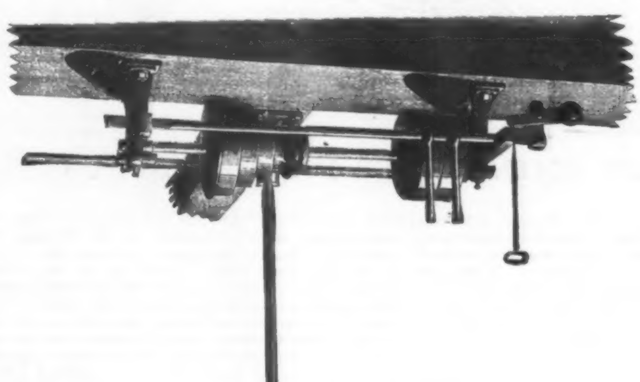
THUILLIER'S SCREW-CUTTING GAP LATHE.

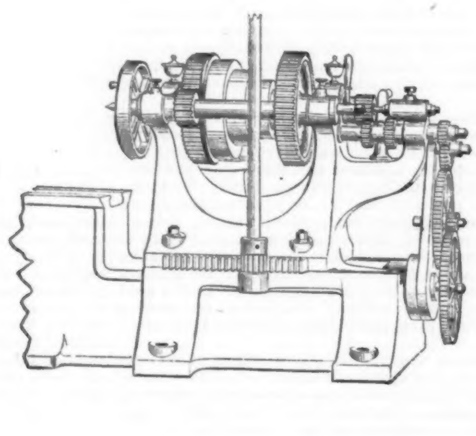
Engine gap lathes, in which the gap is variable in width, have come into quite extensive use by reason of the advantages that they present as regards the mounting of pieces of different dimensions in centers or on the face-plate. However, the arrangement of the lathe-bed in two parts, as adopted, necessitates, on the part of the workman, a certain amount of attention in order to preserve a requisite degree of accuracy in the work; and, besides, the stability of the whole is not perfectly secured. On another hand, in ordinary lathes having an elbowed and fixed bed, it frequently happens that the dimensions of the gap are too short by a few centimeters, and the workman is therefore unable to mount a piece on the machine.

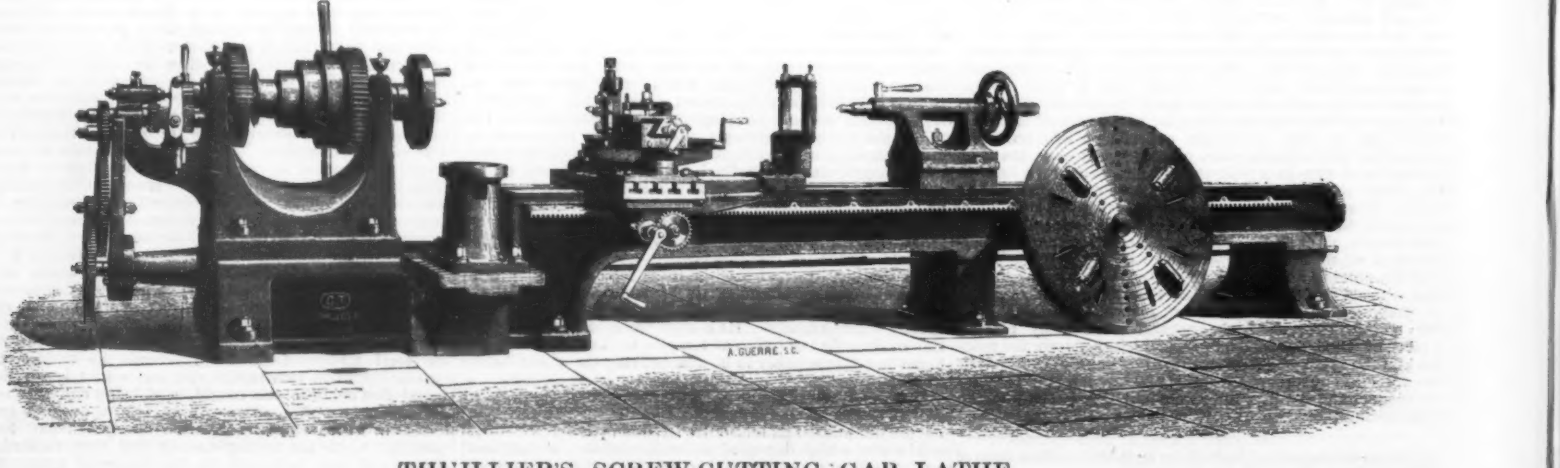
In order to overcome such difficulties, Mr. Clement Thuillier has just patented a new type of gap lathe with elbowed bed, cast in a single piece and provided with a mechanical movement, which permits of varying the width of the gap at will.

The general and detail views that we present herewith show very c early how the inventor has succeeded in realizing these two important improvements.

In this new lathe the front of the elbowed bed is surmounted by a movable head-stock, which carries, as usual, all the parts of the driving gear; and, in addition to these, a peculiar mechanism designed to move it along its support, so as to widen or lessen the gap, according to the dimensions of the piece to be worked. The position shown in the







THUILLIER'S SCREW-CUTTING GAP LATHE.

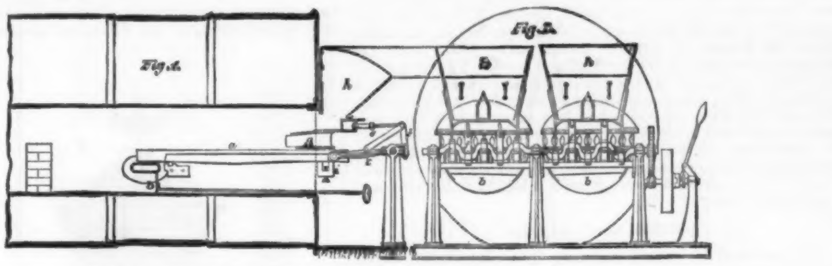
general view corresponds to the greatest width of the gap, and that represented in the figure of the details gives the minimum width.

The movable head-stock, whose shifting mechanism is set in action by a hand-lever, carries on the side opposite that on which the workman stands a rack that engages with a pinion keyed to a vertical shaft. This latter engages at its upper extremity with a similar arrangement, so that, in turning, it automatically displaces the intermediate driving cone, which thus follows all the motions of the head-stock.

The other parts of the lathe are constructed according to the latest models, that have been studied for this special kind of machine-tool. It should be mentioned, however, that the arm attached to the outer standard of the head stock carries a very simple arrangement, which permits of very quickly changing the direction of the running gears, even when the lathe is revolving with great speed.—*Revue Industrielle.*

SINCLAIR'S MECHANICAL STOKER.

ON the present page we give illustrations of the mechanical stoker of Mr. George Sinclair, of the Albion Boiler Works, Leith, N. B. This stoker has now had a trial of four years, during which time it has been applied to upwards of two hundred boiler furnaces, effecting in most cases an important saving in fuel and an increase in the production of steam, with, at the same time, an almost complete cessation of the evolution of smoke.



THE SINCLAIR SELF-ACTING STOKER.

Referring to the illustrations, it will be seen that the fuel is placed in a hopper, *h*, from which it descends by gravity on to a combined dead plate and pusher, *g*, which reciprocates slowly to and fro in the mouth of the furnace. As the pusher is drawn outward the fuel drops from its forward edge on to the bars, and as it is moved inwards it forces the whole body of the fire forwards, at the same time partially closing the outlet from the hopper. The bars do not extend to the bridge, as is usual, but are stopped short at some considerable distance from it, their ends resting on a cross water tube. The incombustible portions of the fuel, when they have traversed the length of the bars, fall over their ends into the flue, from which they are removed from time to time through the door, *b*. To assist the carrying action and prevent the air inlet spaces being choked by clinkers, a reciprocating motion is imparted to the firebars, adjoining bars moving in opposite directions. Both the bars and pusher are operated from one crankshaft having five cranks; three cranks are connected to one set of bars, and two to the other set. Each connecting rod, *e*, from the latter cranks, has a horn piece, *f*, from which a second rod, *e*, imparts motion to the pusher. At *g*, are a series of blocks of fireclay, these blocks being hollowed out on their vertical sides, as shown in Fig 2, so as to leave channels through which air can pass to the grate.—*Engineering.*

CONTINUOUS PRESS FOR SUGAR WORKS AND DISTILLERIES.

WE illustrate in the accompanying plate a type of continuous press invented and manufactured by Mr. A. Dujardin, of Lille.

The press is shown in elevation and longitudinal section in Figs. 1 and 2. Figs. 3 and 4 are transverse sections on the line 1—2, and represent two different arrangements. Figs. 5 to 8 indicate a few details of the cylinder.

Generally speaking, the press consists of two cylinders, C, of bronze, revolving in opposite directions within a chamber with eccentric sides, into which is forced the material whose juice is to be extracted. This latter, after being expressed by the mutual action of the two cylinders, whose surface is perforated, passes into the interior and flows out through a conduit, *b*, in the frame, B. The upper surface of this frame receives the chamber for the cylinders, and the four pillow-blocks in which the shafts, *a*, revolve.

The apparatus is supported by four legs cast in a piece, and so arranged that they may be bolted firmly to the floor. Each cylinder consists of two bottoms, C′, connected by thirty-four bars, C, having a triangular section and spaced at equal distances apart, as shown in Fig. 6. Both the cylinder bottoms and the bars are of bronze. The bars are held in place by large rings, C^2, placed internally, and by a large number of small rings, *c*, 3·5 mm. wide by 5 mm. thick, arranged externally at intervals of 3·5 mm.

Each cylinder is covered with a filtering surface formed of sheet brass, 2 mm. thick, perforated with cylindro-conical apertures arranged quincuncially and spaced one millimeter apart. The conical part of these apertures is directed externally, as seen in Fig. 7; the diameter of their cylindrical part is 0·4 mm.

In order that the filtering jacket may be easily replaced in case of accident, it is divided into four juxtaposed parts that completely invest the surface of each cylinder. Each of these parts has a rectangular rabbet at one extremity which is set into a groove in the cylinder. The other extremity remains free. The filtering surface obtained in this way produces a very regular and remarkable separation of the beet juice from the pulp. The small size of the orifices prevents the passage of solid matters, even the finest, and secures the almost absolute elimination of the pulp.

The cylinders thus constructed are keyed upon parallel shafts, *a*, *a*′, which are prolonged beyond the bearings, A, A′; one of them to receive a pinion, *f*, and a helicoidal wheel, *e*′, and the other a pinion, *f*, like the pinion, *f*, and gearing with it.

The wheel, *e*′, is actuated by an endless screw, *e*, on the axis of which are mounted two pulleys, one of them loose and the other fixed. The screw, *e*, revolves in oil contained in a semi-cylindrical reservoir, E, which is bolted to the frame, and with which are cast in a piece the two bearings that support the screw.

The cylinder chamber is formed of a cast iron casing concentric with the cylinders, and placed 30 millimeters from them. At its two extremities are cheeks, D′, each of which receives a bronze ring, *d*′, provided with two channels, and the position of which may be regulated by means of the screw, *d* (Fig. 5). The cheeks are further connected by two conduits, G and G′, which serve to distribute the pulp.

The cylinder, C, is partially covered with a piece, K, so as to leave a certain interval in which the pulp is compressed after being flattened between the two cylinders. The width of this interval is regulated by means of the screw, d^2. The piece, K, for this purpose, is made to revolve on an axis, *k*, which traverses it, and which also serves as a cross-stay to the two cheeks, D′. Between the pressing piece, K, and the upper side of the conduit, G, there is a cast iron piece, L, which is held in place very near the cylinder by means of small screws. A piece of copper, *l*, is interposed and forms a flexible joint.

The role of the pressure chamber is very important, for it permits of producing a very strong pressure, whatever be the nature of the pulp.

On leaving the press, the pulp detaches itself from the cylinder in a continuous sheet of the same thickness throughout the length of the cylinder, and runs along an apron, T. The expressed juice, as we have already said, enters into the cylinders, and from thence flows to the conduit, *b*.

In Fig. 4 is shown a modification which permits of distributing the pulp each side of the press, and of thus doubling the production.

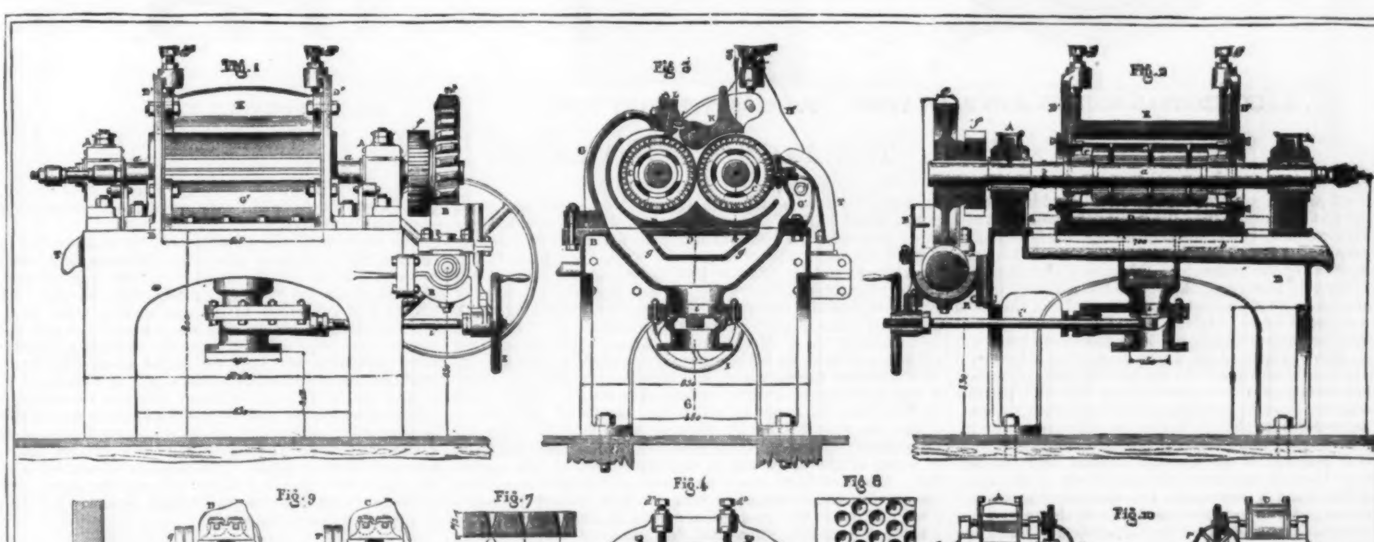
The velocity given the cylinders is 7 revolutions per minute, and the press, at this rate, can treat 40,000 kilogrammes of beets per day. With a velocity of 7½ revolutions, 50,000 kilogrammes may be treated.

The installation, shown in Figs 9 and 10, is a type for annexed rasping mills, or small distilleries. It consists of a series of two continuous presses, A and B (the first, only, visible in Fig. 10), designed to effect the first pressing. Two other presses, C and D, placed one behind the other, in Fig. 10, are utilized for the second pressing. In Fig. 9, only the two latter presses are seen, those of the second series being placed behind.

These four presses are arranged on a floor, under which there are cylindrical reservoirs, A′ and C′, which communicate, the first with the presses, A and B, and the second with the presses, C and D. The material to be pressed is forced into these reservoirs and into the presses by a double-acting pump. The chamber to the right, E′, communicates by a pipe, *a*, with the reservoir A′. The chamber to the left, E^2, seen in Fig. 10, communicates through the pipe, *c*, with the reservoir, *c*′.

The material to be pressed, which is furnished by a rasper fed by a beet washer, enters a vat in which it is intimately mixed by an agitator. Into the bottom of this vat enters the suction pipe, *e*′, of the pump, E′, which latter forces the material to the first-pressing apparatus, A and B. The juice extracted flows into a funnel, I, and the pulp falls into an Archimedes screw, G, placed under the floor, and is carried to a mixer, F, where it is incorporated with a current of water at a temperature of about 40°. At the opposite extremity of the mixer ends the suction pipe, c^2, of the repressing pump, E^2, which forces the material thus diluted into the presses, C and D. The juice issuing from these latter runs into the funnel, K, while the exhausted pulp falls into a second Archimedes screw, H, which carries it directly to the yard.

Power is transmitted to the apparatus by means of eight pulleys keyed to a shaft, T, whose bearings are supported, by means of brackets, on the columns that support the floor. This shaft is actuated by an engine placed alongside of the rasping apparatus. The pulley, L, drives the pulleys, *e*, which actuate the pumps. The sieve boxes of the pumps



DUJARDIN'S CONTINUOUS PRESS FOR SUGAR WORKS AND DISTILLERIES.

are actuated by the pulleys, m, which are set in motion by a belt passing around the pulley, m. The shaft of the mixer is driven by the pulley, N, through the intermedium of the pulleys, n, and gearings, f and f'. The presses, A and B, are actuated by the pulleys, O and P, and C and D by the pulleys, Q and R. Motion is communicated to the screw, H, by the pulleys, S and s.—*Machines, Outils et Appareils.*

NEDDEN'S "KOSMOS" VENTILATOR.

THE apparatus shown in the accompanying cuts is designed for the ventilation of public halls, private residences, and workshops.

It consists (Figs. 1 and 2) of five flat, inclined vanes, B B, of metal, fixed in the center of a turbine or driving wheel, R, which is given a rapid rotary motion to the right or left through the action of a jet of water entering from the conduits, S or S'. These conduits, which are curved at their extremities, are branched over a drum, which is constructed in two parts that carry in their center the bearings of the ventilator axle.

According to the direction of the rotary motion, the vanes, B B, force fresh air into the apartment or withdraw the vitiated air, and force it into an exhaust flue.

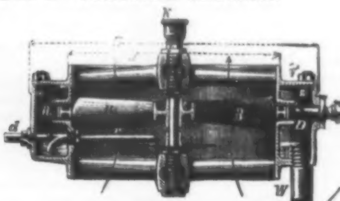
The water utilized for motive power flows through the pipe, W, and may afterward be used for other purposes, its purity not having been interfered with. It permits, likewise, of giving the air a proper degree of moisture. To effect this, a portion of it is directed into an atomizer, placed directly under the vanes, B B.

Finally, in special cases that require the purification of the air, this atomizer receives, through a special conduit, d, disinfecting materials, of which the quantity admitted may be regulated with the greatest precision.

The "Kosmos," for thus this ventilator has been named by its inventor, Mr. Nedden, is constructed in two distinct styles. In one of these, it is inclosed in a jacket having the form of an ordinary stove (Fig. 4), and in the other, it is arranged so as to be simply fixed in the aperture of an exhaust flue (Fig. 3).

The former of these models possesses an external tube, Z, which is connected by rubber tubing with the water pipe; at its base there is a discharge pipe, W; and at the side there is an inlet for fresh air, the entrance of which is regulated by a damper maneuvered by a handle, D.

FIG. 1.—VERTICAL SECTION.



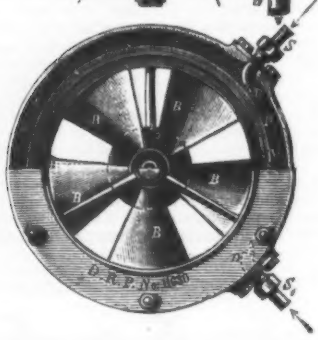


FIG. 2.—HORIZONTAL SECTION AND PLAN VIEW.

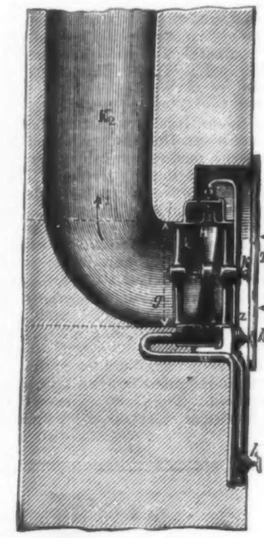


FIG. 3.—STATIONARY TYPE.

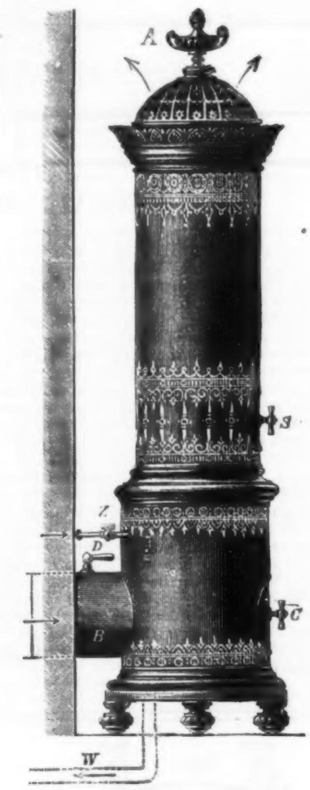


FIG. 4.—MOVABLE TYPE.

THE KOSMOS VENTILATOR.

On the feed pipe, Z, are branched two cocks, which should never be open at the same time. When one of these is turned so as to allow water to enter, the ventilator within the jacket is set in motion and forces the air entering through B in the direction showed by the arrows, A. When this cock is closed and the other one is opened, the ventilator revolves in the opposite direction and draws in the impure air from the room and forces it out of doors. In the first case, the operation of the ventilator permits of blowing into an apartment fresh and heated air, whose temperature and volume are determined according to local conditions. In the second mode of action, the aperture, disengaged by maneuvering a valve, C, permits of ventilating the room by sucking in fresh air from without.

It will be understood that it is easy to alternate these effects so as to obtain, under the best possible conditions, ventilation with renewal of air through suction and forcing. The inventor likewise applies to the upper part of the apparatus just described a serpentine for superheating the air drawn in. In order to moisten this latter to the proper degree, the squared end, a, of a rod that controls a valve inside the apparatus is maneuvered by a socket key. The volume of water to be admitted to the atomizer is thus regulated in such a way as to moisten the air according to requirements. This facility of maneuvering is one of the principal advantages of the movable apparatus.

Fig. 3 represents the same system applied in a dwelling, and installed without communication with an air pipe. It is adapted for purifying and refreshing the atmosphere of a room by sucking up the vitiated air and substituting therefor pure air coming from without, either through the windows and doors, or through properly arranged draught holes. The apparatus is constructed on the same principle as the foregoing. During its operation, the water under pressure that has not been utilized for refreshing the air accumulates in the lower part of the drum and flows out through the discharge pipe, W. The feed pipe reaches to the top of the drum and carries the cocks, h, which control the entrance of the water which runs the ventilator.

The stationary type may be set up in either a horizontal or vertical direction, and works equally well as a suction or force apparatus.

To set the apparatus (Fig. 4) running, the cock on the tube, Z, is turned on after ascertaining the position of the valve, a; and then the valves, S, B, and C, having been put into the position corresponding to the mode of ventilation, the feed through the cock, h, is regulated in such a way as to secure continuity and regularity in the working. If it is necessary at the same time to disinfect the air, the extremity of the atomizer tube is coupled with a receptacle containing the disinfecting materials.

According to all the accounts that have reached us, these apparatus work silently and are not liable to be stopped through choking up of the conduits. The quantity of water they use is slight, and may be proportioned to the conditions of the work by the simple maneuver of a cock.—*Revue Industrielle.*

THE ANTWERP WATER WORKS.

AT a recent meeting of the Institution of Civil Engineers, London, the paper read was on "The Antwerp Water Works," by Mr. W. Anderson, M.Inst.C.E. The author commenced by stating that in 1879 the concession for the supply of water to the city of Antwerp fell into the hands of his firm. Antwerp had a population of 200,000 inhabitants; it ranked as the third largest port in Europe, and was being rapidly extended and embellished. Previous to the construction of the works, the water supply was derived from shallow wells and open canals. As the sewage arrangements were very imperfect, the well-water, though clear, bright, and sparkling, was, for the most part, dangerously contaminated. The scheme adopted by the author's firm, the only one practicable from a financial point of view, was originally suggested by Mr. J. Quick, M.Inst.C.E., and consisted in taking the waters of the river Nethe, an affluent of the Escaut, at a point eleven miles from Antwerp, where it was crossed by the Malines road. The waters of the Nethe were, however, quite unfit to compete with the existing supply, after only ordinary filtration through sand, because they were greatly colored by peaty matter and very finely-suspended mud, which could not be separated either by subsidence or filtration. Moreover, there would have been great risk in introducing into an important town water from a river which flowed through a highly cultivated and populous country.

SPONGY IRON FILTERS.

The attempt to supply Antwerp from the Nethe would probably never have been made had not Professor Bischof's process of filtration through spongy iron come under the notice of the author. The properties of finely-divided metallic iron as a material for filters had, for some time, attracted the attention of chemists. Professor Bischof, Dr. Frankland, and Mr. Hatton had demonstrated that it possessed the power of destroying organic impurities, removing color, separating finely-suspended matter, softening, and, above all, destroying the germs of putrefaction, of bacteria, and probably those of epidemic diseases. To confirm the evidence afforded by laboratory experiments, and by spongy iron domestic filters, which had been in use for some time, it was determined to carry out experiments on a large scale at Waelhem, the proposed site of the intake of the works, under the auspices of Mr. Ogston, Ass.Inst.C.E. The arrangement recommended by Professor Bischof took the form of a pair of filters, having an aggregate area of 680 square feet. The first filter was to be placed on a higher level than the second, and to be filled with a bed of spongy iron and gravel mixed in the proportion of one to three, covered by a layer of ordinary filter-sand, the office of which was to separate the grosser suspended matter. In this filter the water would become charged with iron, to eliminate which it was to be exposed to the air, and passed through a second or sand-filter, in which the red oxide would be deposited. The experiments were carried on for three months, and proved so satisfactory that all doubts about the efficacy of the process were removed, and the designs were made for the permanent works.

The terms of the concession required a daily supply of 33 gallons per head for 175,000 inhabitants, or nearly 6 million gallons per day; but, in the first instance, the pumping machinery and main were to be laid down for only 40 per cent. of that quantity. The works consisted of a 42-inch intake-pipe, two settling ponds of an aggregate capacity of 2,640,000 gallons, a pair of Airy's screw pumps, worked each by an independent engine, for raising the settled water 19 feet into the spongy iron filter beds; three spongy iron filters, having an aggregate area of more than 31,000 square feet, three sand filters of the same area, two cast iron filtered water-tanks, containing together 340,000 gallons, and two pairs of beam pumping engines, of 170 horse power each, together with their boilers and fittings. The Nethe being a tidal river, carrying up the drainage of Malines on the flood and bringing down that of the villages on its upper waters on the ebb, the authorities prescribed certain limits within which alone the waters should be taken; these restricted the time available for filling the settling ponds to about three-quarters of an hour in each tide. The settling ponds, of a capacity to hold twelve hours' supply, were excavated immediately in rear of the river bank and lined with dry stone pitching. The nature of the ground was exceedingly treacherous, a bed of water-logged silt extending under the whole area a depth of six or seven feet below the surface; it was thought prudent, therefore, to construct the filter-beds entirely of earthwork resting on the surface, and to trust to puddle linings to secure the necessary water-tightness, and to adopt pile foundations for the engine-house and chimney.

The environs of Antwerp being very flat, did not permit of a high-service reservoir being constructed; the filtered water-tanks were therefore placed close to the engine-house, and the service was maintained by uninterrupted running of the engines, which, for this purpose, were arranged in pairs, each pair coupled at right angles, so that they could run at any speed between 1½ and 22 revolutions per minute. To provide against the effect of frost, the novel expedient was adopted of heating the water as it flowed to the screw pumps by means of injected steam, the author stating that the experience of last winter seemed to indicate that the arrangement would prove efficient. The result of eighteen months' working had been very satisfactory, the water having remained pure, bright, and clear throughout the time. The spongy iron had not shown any signs of deterioration or wasting; and Dr. Frankland who had visited the works, had reported very favorably of the process employed, not only with respect to the chemical condition of the water, but also with reference to the complete destruction of bacteria and their germs.

The water from the pumping-station was carried in a 20-inch main for ten miles along the Malines road; its course was described at length, together with the appliances for getting rid of air and of avoiding dangerous shocks. The distribution of subsidiary mains and service pipes in the city was explained, together with the manner in which the various services were laid on. By the system adopted, a constant circulation was kept up as far as possible in the distribution pipes throughout the city. It permitted a range of pipes to be shut off without stopping the supply of the neighboring streets, and even often enabled the service to be kept up when portions of one of the mains had to be shut off. A comparison was instituted as to the relative cost of German and English pipes. The manner of testing, as fast as the pipes were laid, was described, and the paper concluded with the statement that the works were erected in fifteen months at a cost of £280,000.

SAFETY APPLIANCES FOR BUILDINGS.

To the Editor of the Scientific American:

Referring to what is said on page 50, SCIENTIFIC AMERICAN, January 27, 1883, in regard to "vigilance in building," the want of which has recently been so painfully illustrated, I would revive an old suggestion of mine as to the mode of constructing buildings for the manufacture, sale, and storage of valuable goods.

It is well known that more damage is done in many cases to goods than to the buildings themselves; water poured into upper stories runs freely down to the lower floors and spoils goods and machinery in spite of the water-tight coverings of the insurance agents.

My remedy is this: To have double walls with a space of four or five inches between them and to *plaster directly upon the bricks*, have iron beams and a gutter of the same *all round each floor*; lay the floor as a ship's deck is laid and calked, so that all water thrown in shall escape by the gutters, or "water ways," by means of scuppers and conductors, through the spaces between the walls; and, to be complete, let this water run into a large cistern in the cellar, or near it, so that it can be used again and again.

There may be some practical difficulty in surrounding scuttles and elevator spaces by coamings to prevent the water from running down into the lower stories. It will not require a large amount of ingenuity to carry out my plan effectively. Of course, the plan will be more costly than making floors like sieves, but the saving of property ought to compensate largely for this extra cost.

When we see the palace like erections in the burnt districts of Boston and other large cities and consider the cost of the materials, I cannot but think that water-tight floors would be in much better taste and save millions.

If space would admit, I might enlarge on life saving means for hotels and tenement houses; but I shall not trespass on your valuable space further than to suggest means to throw life saving appliances *from the buildings opposite to fires;* the simplest thing would be hand lines with a weight at the end, such as I have often seen used by tug boats to throw a line on board of a vessel in a rough sea way. A line of Manila of one-quarter or three-eighths inch diameter can be thrown from a roof across the widest street in Boston by a trained fireman, and by this means a larger rope or a canvas chute may be hauled over and do good work, much more easily than the same things can be thrown up from a street. A common bow and arrow may be used also, and perhaps with better aim into a window.

I have lately noticed that in London the canvas chute is in use for getting people down from high buildings, but it must be a heavy affair, costing more than we can afford, perhaps, and it would be subject to being wetted and frozen in very cold weather.

If these suggestions should be thought worthy of discussion, I trust you will publish them. R. B. FORBES.

Milton, Mass., January 29, 1883.

HOW TO SEASON LUMBER.

THE advantages of seasoning lumber by artificial means are too well known and appreciated at the present time to require extended argument in favor of the system. It is a subject of more than ordinary interest to lumbermen just now, for the reason that the natural changes in methods of doing business actually necessitate some quicker process of drying lumber than open air seasoning. Saw-mill men especially, whether sawing the white pine of the Northwest or the yellow pine of the South, are beginning more than ever to realize the importance of the planing-machine and the dry-kiln as factors in the successful prosecution of their business. Long shipments by rail cannot be made profitable unless the product to be transported is first shorn of every pound of superfluous weight. Shavings, edgings, and trimmings are more profitable as fuel than when adding their extra weight to a consignment of lumber destined for a distant dealer, who will not pay as much for the rough as for the dressed material.

The same is equally true regarding the surplus moisture contained in green or half-dried lumber. The shrewdest lumberman in this country cannot make it profitable to pay all the way from 18 to 40 cents per hundred pounds on water, and every thousand feet of green white pine lumber, fresh from the saw, contains just about 2,000 pounds of moisture that a few days' treatment in a dry-kiln will expel from it. In yellow pine and the various hardwoods the necessity for drying becomes greater in proportion to the difference in weight.

The accompanying drawing will convey a tolerably clear idea of the most approved modern method of constructing lumber driers. The kiln will doubtless be recognized by a majority of the readers of this paper as the Excelsior and Chicago, built by Messrs. Curran & Wolff, of this city, and which has been almost universally adopted by the leading lumberman who use driers at all.

Figure 1 is a longitudinal, sectional view, which really shows the construction and method of operation so clearly as to render further explanation almost superfluous. The lumber, loaded upon cars, which are exclusively Curran & Wolff's patent, and which are one of the most important features of the kiln, as will be noted more at length later on, is introduced at the front or chimney end of the drier, the floor of which, as shown by the dotted "level" lines, is an inclined plane with a fall of two feet at the rear end. When a car is removed the others are readily moved forward, mainly by the natural law of gravitation.

Fresh air is introduced at the same end of the kiln as the lumber, under the front platform, and passing through the steam coils, arranged in gates, as shown in Figure 4, and still more clearly in the perspective view, Figure 2, it, now thoroughly heated, enters the drying chamber through a trap in the floor at the extreme rear. The draught chimney at the front, which is carried to a sufficient height to create a powerful suction, draws the heated air through the lumber at the rate of a moderate gale.

The current of hot air is forced to go through instead of over the lumber, by the hanging of a curtain against the first car of lumber which it meets, from the ceiling, and at various intervals through the kiln similar curtains are hung from the ceiling to the lumber, the last one at the mouth of the chimney, being brought down to within a short distance of the floor, practically exhausting the air from the bottom, and carrying away the dead and moist air, which always falls by reason of its greater weight. This, as may be readily seen, insures a thorough, even, and rapid circulation of hot air all through the lumber as it is cross-piled on the trucks.

The construction of the drying chamber is better shown in the cross section, Figure 4. The walls are all hollow, and the space filled with sawdust, rendering them excellent non-conductors of heat. The space under the floor, marked "dead air chamber," is also filled with sawdust. The improved truck, before referred to, and which is shown at Figure 5, consists simply of two side pieces having two wheels each, with no connection between, the lumber piled across them constituting the balance of the car. The wheel, as will be observed, has a central flange running between two light T rails, something radically different from the ordinary car wheel. This method of construction prevents all liability of the car to get off the track, as those made in the old way were quite apt to do. The trouble occasioned by a car jumping the track in the middle of the kiln would be of a very serious and expensive nature, as all the cars would have to be unloaded from the end nearest in order to get at it. It is practically impossible to run one of these trucks off, and besides being strong, they are exceedingly light to handle. After unloading, a man can pick up one of the sides and easily carry it to the front of the kiln ready to be loaded again. Sometimes a track is built outside the drier on an incline, upon which the trucks may be placed to roll back to the front, after the manner of the balls in a bowling alley.

The Excelsior and Chicago drier, as now constructed, is the result of many years of experience in kiln-building, and it may be said to embody all the features of any account in the rapid and successful seasoning of lumber. While it may be adapted to the requirements of any kind of an establishment, great or small, it is unquestionably the drier for large operations. In their illustrated catalogue the makers give a list of establishments now using their driers, which includes many of the largest saw-mills, planing mills, car shops, sash, door, and blind and furniture factories in the country, the territory embraced extending literally from Maine to Texas.

An important feature of this drier is the quality of the iron pipe used by Curran & Wolff in its construction. It is what is known as lap welded, and is all made in 16 foot lengths, requiring no coupling, each gate being attached to the main supply and exhaust pipes at either side. The arrangement of the pipes in gates is original with Curran & Wolff, the heating capacity of the same quantity of pipe being increased about 40 per cent. over the method originally employed in building the old Sumner kiln.—*N. W. Lumberman.*

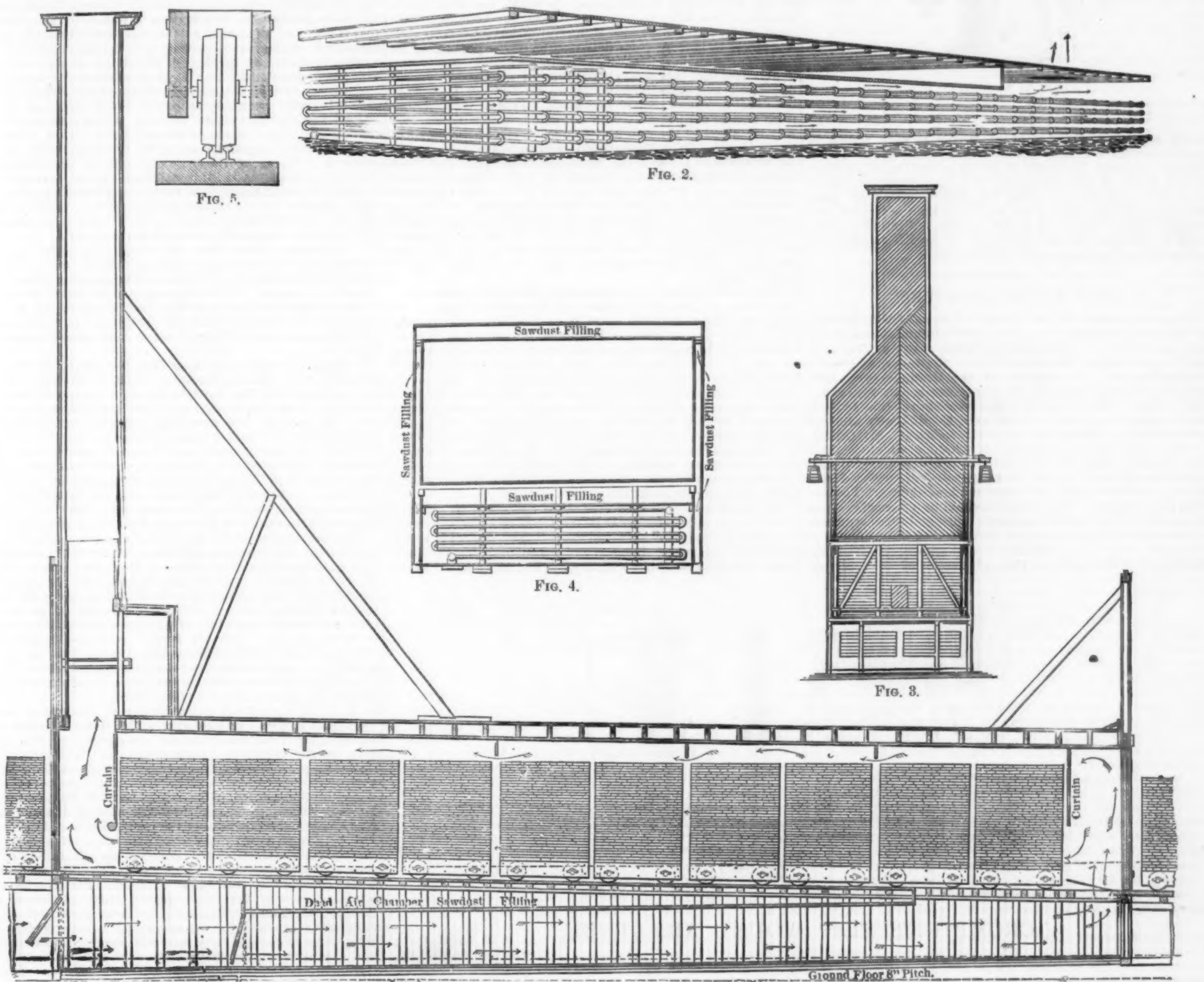


FIG. 5. FIG. 2. FIG. 4. FIG. 3. FIG. 1.

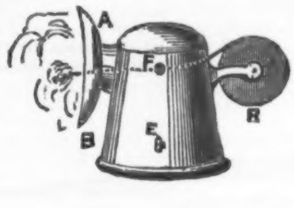
THE EXCELSIOR AND CHICAGO LUMBER DRIER.

REMARKABLE AUSTRALIAN ARTESIAN WELLS.

A NEW artesian well at Sale, with its outflow of over 400,000 gallons of water a day, rising 12 ft. above the surface, is a great success. The town is jubilant over the supply of pure water thus easily and cheaply obtained. The recent sinking of an artesian well by Mr. De Renzil Wilson on Tatara Run, near Curriwillinghi, on the New South Wales side of the Queensland boundary, where at the depth of 200 ft. a spring was tapped, which forced itself to the height of 15 ft. above the surface, and at the estimated rate of 500 gallons per minute, is even a more gratifying success. This is at the rate of 720,000 gallons per day.

M. LOISEAU'S MAGNESIUM LAMP.

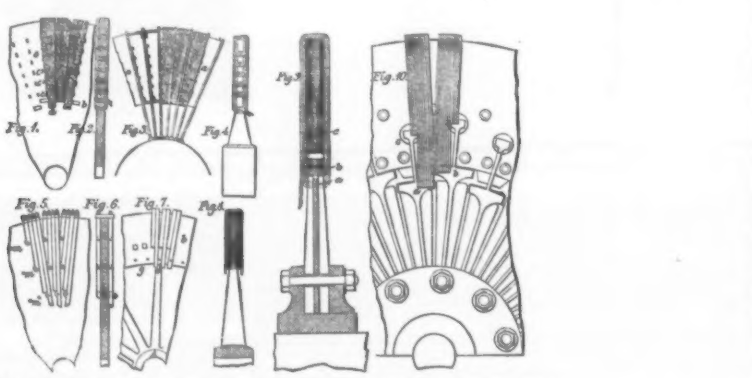
A MAGNESIUM lamp regulated by clockwork was lately presented to the Photo. Society of France by M. Loiseau, of Rue Richelieu, Paris. This pattern, smaller than the ordinary lamp, and at the most moderate price of eighteen francs, may be of great use for photographic work requiring artificial light. It is very portable, and I think a lamp of this kind is indispensable to the kit of a tourist photographer. The earlier lamp was certainly very heavy and large. Very often while traveling one longs to reproduce the interiors of grottoes, caverns, etc.; an article of this kind so simple, compact, and portable, would answer the purpose satisfactorily. Although the reflector measures only from six to seven centimeters in diameter, its great curve diffuses the light across a wide field, about four meters in diameter, at the distance of about three meters. This is sufficient for rapid plates working with a lens having a wide angle. The subjoined diagram shows the simple arrangement of this



useful apparatus, the height of which is only eleven or twelve centimeters, the length about the same. A B is the reflector, through the center of which passes the magnesium ribbon, L; M N is a cylindrical box containing the clockwork motive power; R is the wheel upon which the magnesium ribbon is rolled, from which it passes across the box through the reflector; E is the key for putting the clock work in motion; and the button F, is used for regulating and stopping the mechanism.—*Photo. News.*

STEP WOUND ARMATURE.

IN all ring armatures the number of turns of wire that can be applied is determined by the inner circumference of the ring and there is, consequently, vacant space at the periphery equal to the difference between the inner and outer circumferences. In machines of the Gramme type, this, says *Engineering*, does not amount to much, but with armatures whose radial width is considerable in relation to their width measured parallel to the axis, the difficulty becomes serious and has hitherto been a bar to their use. Mr. Crompton has lately devised a method of winding, which he calls step winding, whereby this waste of space is avoided, and the whole of both faces of the ring or disk are covered with wire as well the inner and outer circumferences. The method is as follows: The disk is divided into segments equal in number to the intended separate coils, and these segments are wound with as many equal and parallel turns of wire as the length of the inner circumferential arc will admit of; the winding is then continued through a series of holes pierced



CROMPTON'S STEP WOUND ARMATURE.

through the disk, or steps cut in the segment in such manner and order that each successive turn of wire, or groups of turns of wire, is rather shorter than the one preceding it. In this manner the otherwise unoccupied triangles are filled up with winding in a series of turns, or groups of turns, arranged stepwise, so that the whole of the wedge-shaped segments are completely covered.

Figs. 1 and 2 illustrate one method of carrying out the invention. In this the winding of one of the segments is commenced at the oblong hole, *a*, and is continued, as above described, until the hole, *a*, is filled with wire. After this the winding is continued through the holes, c_1, c_2, c_3, until the full length of the outer bounding arc of the segment is filled. The next segment is then commenced at the hole, *b*, and the winding continued all the way round in a similar manner, each section being formed of as many layers as may be convenient.

Figs. 3 and 4 show another method of winding applicable to a disk core built up of segments. Each section is of malleable cast iron or other magnetizable material, and is formed stepwise along one edge, as indicated at *a*. The segments are secured together in pairs in such manner that they form a rigid compound segment capable of withstanding the tangential strain caused by the rotation of the disk. By this arrangement the respective segments can be wound separately and built up into the disk, and, if necessary, be subsequently removed and replaced without disturbing the other segments. The winding is similar to that shown in Fig. 1, and each segment can be coiled before it is bolted to the next.

Figs. 5, 6, 7, and 8, show two disk armatures in which the conductors are thick copper bars, *m m*, each of which consists of a stirrup of rectangular section. The connections between adjacent turns are made by copper bolts passing through holes in the disk, which may be made either of several thicknesses of iron plate riveted together, or of a rim of non-magnetizable metal, covered with iron plates, as in Fig 7.

Figs. 9 and 10 show a modification, in which the holes, *a* and *b*, corresponding to the holes, *a* and *b*, in Fig. 1, are connected to radial slots extending to the inner circumference of the plates. This affords facility in winding, as by this device the wire can be wound on a bobbin and passed through the central hole of the disk.

THE RADIATION OF COLD.

To the Editor of the Scientific American:

The discussion of this subject in the columns of the SUPPLEMENT, has thus far been only superficial. It is altogether possible that a more complete analysis of the problem may result in a harmonizing of views which seem to be mutually contradictory.

Mr. Gordon presents arguments to show that relatively cold radiations have a positive power to reduce the temperature of objects upon which they fall. My mind was so far dominated by preconceived theories that I failed to apprehend his real meaning, couched as it was under an apparently paradoxical statement. That meaning seems to be that rays which cause the thermometer to fall are of the same nature as the rays which we recognize as warm, and that consequently if the latter have power to communicate to matter their molecular motion the former must have a corresponding power to take up from the same matter a portion of its molecular motion—in other words, to cool it.

I confess that this reasoning admits of no answer, except one based on a knowledge which we do not yet possess of the exact nature of radiant heat itself. This view commends itself also as harmonizing with our common experience, and it is sustained by the well known phenomena of the focalization of cold. Why then should science hesitate to accept the doctrine? I think the main reason has been that if we adopt this explanation in regard to bodies which are only relatively cold, we must either extend it to those which are absolutely devoid of heat, *from which, therefore, no thermal radiations proceed*, or else we must suppose that a body which at a temperature one degree above the absolute zero is capable of refrigerating powerfully surrounding objects loses that power instantly, if deprived itself of the little heat it still possesses.

But are we driven to this dilemma? The tacit assumption, of course, is that a body possessing no heat will emit no radiations; that radiations, apart from the light or heat they carry, have no existence. I believe, not only that this assumption is in itself unwarranted, but that science is already in possession of evidence that such radiations exist. I need only allude to the phenomena of gravitation, and to the hitherto unexplained circumstance that light rays, however they vary in the rapidity of their peculiar undulations, have the same velocity in traversing space, to indicate the nature of that evidence. Whether this property of radiation belongs to the atoms of matter, or whether it is an attribute of a fluid (ether) which has an existence independent of matter, such a property is manifested in connection with the phenomena of light, heat, and gravitation.

We may figure to ourselves these radiations as ethereal particles, as much smaller than the atoms of ordinary matter as these are smaller than the planets and the suns which circle through space, flying in every direction like the molecules which make up an ordinary gas, but so minute that the "mean free path" of each particle is possibly millions of miles in length.

The impact of these particles upon material atoms gives rise to the phenomena of gravitation, according to the well known theory of Le Sage, while their vibrations constitute light, or give rise in material bodies to the manifestations of heat. Thus is reinstated incidentally Newton's corpuscular theory of light, only, like Newton, we must bear in mind that we are picturing to the imagination the unknown by something only remotely analogous in the known.

It will be seen that the theory I have attempted to outline does not contradict the doctrine of exchanges; it only explains in a new way the manner in which exchanges of temperature are effected; at the same time it allows us to conceive of cold rays as well as of warm ones as actual entities, and it thus saves science the necessity—always irksome—of explaining away the positive testimony of the senses.

I have made no allusion to my attempted argument in a former communication (SUPPLEMENT, Feb. 10), although I am aware that some of the logic of that argument in the light of the views I have now attempted to explain will be seen to be very lame, and I wish to make to your readers in general, and to Mr. Gordon, in particular, the *amende honorable*, for the dogmatic and in so far unscientific tone of that communication.

A. B. LYONS, M.D.

Feb. 12, 1883, Detroit, Mich.

THE officers of Engineers in Berlin are making interesting experiments in war balloons, and in photographing from a height sufficient to be out of range and command a view of the surrounding country, in spite of a rapid rise. By means of an electric apparatus a plate has been secured in less than a second.

A REVIEW OF THE DOCTRINE OF ETHER WAVES AND OF THE MATERIAL NATURE OF LIGHT.

By ELLEN R. PRESCOTT.

I.

THE theory of an intangible luminiferous ether, filling space and permeating all bodies, has been used as a simple adjustment of thought to recognized physical phenomena. When Dr. Young, reasoning from analogy in sound waves, had demonstrated that our sensation of light is the result of the impact or vibration of matter upon the retina of the eye, thence conveyed by contact to the nervous system, it was necessary to establish in the mind some idea of the physical condition of matter by which this impact could be effected.

The denser substances by which we are surrounded, solid, liquid, and gaseous, responded to the wave theory of sound for contingent bodies, or bodies at appreciable distances; but in applying this law to the finer mechanism of light, and in projecting our experiences of the sensible vibrations of material media through stellar distances, and among stellar masses, there must be, as has just been said, some corresponding means of communication.

Prof. Tyndall in "Scientific Use of the Imagination," says "that in studying the phenomena of sound we rise but little above downright sensible experience. That while the picture presented to the mind of sound waves is a purely imaginative production, imagination is so aided by the senses that it plays no dominant part in this mental process. The velocity of sound waves accords with the disturbance or vibration of the denser medium of the air, the *thrills* of which are made sensible to us. It is in adapting this sensible mechanism of sound to the subsensible mechanism of light, that it becomes necessary to assume the existence of an infinitely lighter, more elastic medium, which is responsive to the infinitely finer, quicker waves of light. Thus what reason demands, imagination supplies" by boldly diffusing in space a medium of the requisite tenuity and elasticity. Then reasoning "as if" this medium existed, and deriving in every case and throughout every complexity the result of light, as in the known conditions of matter we realize sound, we are forced in the one case, as in the other, to visualize the vibrating atoms of the air and of the ether.

Nevertheless, even while assuming and reasoning profoundly upon his assumption, Prof. Tyndall thinks "it will be well to keep the theory of a luminiferous ether plastic and capable of change." Further, he quotes Sir David Brewster, "that his chief objection to the undulatory theory of light was, that he could not think the Creator guilty of so clumsy a contrivance as the filling of space with ether to produce light."

Physical investigations later than Sir David Brewster's, however, prove that the luminous track of the spectrum is only a connecting link between the wide sweep of invisible activities in the chemical rays above and of heat-motion below. If, then, he had associated with the transmission of light by ether the action of the correlative physical forces, his views of the "clumsy contrivance" would have been modified. Nevertheless, with even these additional functions imputed to this assumed tenuous agent, the mind accustomed to the nice adjustments of nature involuntarily protests against the filling of space with ether for the sole purpose of transmission of one or of a variety of motions.

The idea of any special creation of a tenuous agent for the purpose of transmitting motion seems wholly contradicted by a summing up of the sources in the denser forms of matter from which this ether may be derived. In the active combination and expulsion of combustion, not only interstitial matter is given up, but the framework of gross matter dissolving the molecules from themselves back into space, resolving into their primary atomic condition under repulsive polar force, as from the opposed force of attraction the massing of particles had previously been established. These opposed polar movements become thus the formative and destructive agents of ponderable matter.

The relations existing in matter during combustion under atmospheric pressure extend also to those creative fires whose ashes form new worlds. In our conceptions, however, of the condition under which such combination or combustion could exist, it must be remembered, first, that if pressure be less the point of ignition would necessarily be higher, and secondly, as stated by Meldola, that such combination, although arising from the cooling down of gases previously at a temperature of dissociation, would nevertheless be attended with the evolution of heat and would possess the character of true combustion. In this hypothesis we are led, *a priori*, to a chemical condition or period when compounds can begin to form. The combination would necessarily take place in the outer and cooler portions of the star's atmosphere, the heat given off by the combustion representing the energy of chemical separation. By continued cooling these simple processes of condensation and expulsion repeat themselves over and over again, and "from this behavior of first principles or elements are derived not only all the substances, solids, liquids, and gases of the earth, but of all other forms of matter throughout the universe."

Such are the world fires in the nebular theory of creation. We are, however, led back beyond this point into a gaseous chaos when the whole universe, inconceivable ages ago, was equally filled with a homogeneous mass of tenuous matter at an extremely high degree of temperature. The millions of bodies composing the different solar systems originated only in consequence of rotary movement during which a number of masses acquired greater density than the remaining gaseous mass, and then acted upon the latter as central points of attraction.

Any disturbance of equilibrium, any power producing a first clash of atoms, would occasion the breaking up of this primary nebula, and the attractions and repulsions thus set up by the impingement of atoms in the establishment of their axial and orbital movements, the shifting of temperature, so to speak, the heat evolved by ultimate contact or chemical action, its conduction and convection and the consequent refrigeration by abstraction or removal from other atoms in a dependent relation, would necessarily usher in a formative era. In the massing of matter it is therefore by movements of rotation and movements of revolution, this rotation and revolution being subject to and consequent upon polaric movement of the ultimate particles, that all differentiation arises.

This theory, says Haeckel, is purely monistic and deals with the inherent forces of eternal matter. But the eminent philosopher in accepting this idea of a "raw material," while discarding the traditional six day history of creation, demands of the mind an equally impossible process. By it we are to project thought back through inconceivable ages to a period and condition of gaseous chaos. It is indeed a

vague assumption of a beginning of what, being eternal, had no beginning. We are inevitably led by any reasoning upon rudimentary matter to look for a beginning, or in other words to look for the formation of the "gas" itself. Moreover, the theory "deals with the inherent forces of eternal matter;" and since, if matter be eternal and subject throughout eternity to the action of inherent forces, we can conceive of no period when these forces were in perative, and the raw material of the universe was left to lie unused, while, as has just been said, the inherent organizing, or, to our senses, creative forces were held impotent or inactive. Here, indeed all "logical imaginings" fail, for we can set no limit to the action of natural law, can conceive of no one moment in an unmarked eternity when this manufacture of complex matter out of raw material began. Moreover, there is nothing in our recognition of the behavior of matter to show that there was any period of a first combination, when the gaseous elements were all in like condition. If matter be eternal, then it has existed in some one or in varying conditions, and it is surely as conceivable in subsensible creations as in the visible world around us, that the elements of one substance are the derivatives of previous combination and decomposition, these interchanges being limitless as eternity itself. If out of our coal fires, ay, if out of the breath of our nostrils, nature finds her raw material and builds her nebulæ, and with their on-rolling kindles her suns, and these in burning to ashes give out a life principle to succeeding creations, each of which, dissolving, pours itself back into the bottomless reservoir of creative elements, this supposititious "raw material" takes the form of familiar substances.

The analogies in the molecular constitution of ponderable matter, "the proclivities of atoms toward a particular arrangement," offer presumptive evidence of a like action or of a similar property of arrangement in imponderable matter; in other words, if by polarity we mean that power which the units or atoms of denser matter have of aggregation in special form, while physical experiments prove the same tendency in gaseous forms of matter, we may logically infer that the same laws exist, even where the fineness of matter eludes our coarser reckoning. When Sir William Herschel found what he conceived to be planes of attraction in the "long extended regular or crooked rows, hooks, and branches of nebulous formations," he simply recognized this all pervading tendency of atoms in their aggregation to arrange themselves in special forms, to lock themselves in lines and curves of potential energy, these lines and curves being determined by the inherent electrical or magnetic forces of the atoms.

In this theory of the magnetic force or property of matter which forms and sets the worlds adrift in space, we approach those intimate mysteries behind which nature veils creative power; here, indeed, human thought is lost; but in accepting this as the first recognizable process we establish the conditions out of which masses of worlds and systems of worlds are formed, whose majestic cycles mark the rhythm of eternity. To this point we seem to trace the creation of visible matter. But the matter which thus assumes sensible forms is, to our conception, matter which has been previously involved in other combinations, and which by molecular movement has been thrown from aggregated masses or concrete forms back into the tenuous condition out of which, by its own inherent properties of attraction and combination, it has repeatedly evolved. With this view creation cannot be of a remote and indefinite past, but is *now* a continuous, permanent, and enduring fact, and the formative matter of new worlds is involved in the ordinary substances of our own and of other old worlds, in the varied changes and redistribution of their elements. The massed molecules in breaking up are engulfed in the whirl of atoms moving on ceaselessly through that awful cycle of eternity—lit a single span by human experience and knowledge, dark with a profound mystery beyond.

R. A. Proctor, in his paper upon the "Seeming Wastes of Nature," sums up the vast reservoirs which are continually disgorging their currents of light and heat into space. "Our earth receives less than the two hundred millionth part of the light and heat emitted by the sun; all the planets together receive less than the two hundred and thirtieth part; the rest is seemingly scattered uselessly through interstellar space." He then calculates from the estimates of Sir John Herschel "that of the amount of this heat and light poured upon the earth's surface, the earth utilizes only a force corresponding to about fifty millions out of six hundred millions of millions. And now, remembering that what is true of the sun is true of his fellow suns, the stars, and of all the thousands of stars we see, and the millions within the scope of the telescope and the myriads which lie in space outside, how enormous, then, in accordance with our conceptions, is the waste of force."

Now in the face of such calculations, where we vainly heap up line upon line and number upon number in our effort to grasp the immensity of these actual products of fine matter, the effort of the imagination to diffuse in space a medium of requisite tenuity becomes simply a recognition of the attenuated matter whose existence may be logically accounted for. The ether is thus the legitimate result of the fundamental law of combination and expulsion.

If light and heat be motion, they are the motion of matter; divorced from matter, they cease; hence, force and matter must never be regarded as distinct in nature. On this point Herbert Spencer says that "force is our ultimate measure of matter, and the converse is obviously true. Further, that the force which a given quantity of matter exercises remains always the same, and that the unchanged quantities of matter and motion are proved by the unchanged manifestations of force. The quantity of matter is asserted to be the same because the force of gravity is the same, the matter being necessarily the measure of the force. The result depends entirely upon the constancy of the units of force, and these units of force are the atoms of the matter weighed. Here, then, in gross form, matter acts upon matter without the sensible mediation, for the transmission of gravitative force, of this mysterious ether, which science has treated of as an indefinite immaterial agent. But an immaterial agent is only a form of speech; it represents no mental conception. If, on the other hand, we conceive this ether to be minute diffused matter, the individual molecules or atoms of which are invested with activities which are transferable and mutually interchangeable, and that these exertions or interactions generate the recognized motions of electrical phenomena, of light, and heat, as in ponderable matter we have the manifestation of gravity, we rid ourselves of confusion in the use of the words force and matter.

The conversion of forces is an axiom in physical science, and yet when we seek to establish any law for the conversion of matter or a sequence of form, we are in this very assumption of an ethereal agent involved in inexplicable confusion; for whenever we mentally attempt to divide any amount of force into its constituent portions, then every portion, however minute, of the force must have a corresponding portion of the matter to which it is inherent, and without which the force cannot be thought to exist.

In "First Principles," we are led still further into a consideration of the relation in the convertibility of force and matter. By an aggregation of atoms their relative motion is necessarily diminished. By expansion or separation greater relative motion is imparted. The form of the mass, therefore, depends wholly upon the rates of internal motion of the constituent particles. Now, all things are growing or decaying, expanding or contracting. Both the quantity of matter and the quantity of motion contained in an aggregate, while constant in proportion, vary in amount. Hence, it follows that there are continual changes in the resultants, and that these changes depend upon the relation or arrangement of the atoms. By the present hypothesis of molecular action, this property of arrangement depends upon the inherent attraction and repulsion, upon the polar force of ultimate atoms. Thus, then, throughout a continual change of products, the quantitative relations being invariable, we are met by the same invariable fundamental law, that upon polar action, upon a primordial impulse of matter, all subsequent behavior depends.

Matter thus becomes a force-giving agent, holding it as potential, or giving it out by a changed relation or condition as dynamic. Each molecule is compounded of atoms, each atom of which becomes an engine of force. when the static condition of the molecule is broken up into the activities of the atom.

This necessarily involves the idea of the molecular constitution of ether, and resolves the ether into ordinary matter in its widest limits of expansibility. Upon this point, Sir William Grove thinks it more consistent with known facts to regard light as resulting from vibration or motion of the molecules of matter itself rather than from a specific ether prevading it, just as sound is propagated by wood, or as waves are by water. At the utmost, he continues, "our assumption is that whenever light, heat, etc., exist, ordinary matter exists, though it may be so attenuated that we cannot recognize it by the test of other forces, such as gravitation.

"The enormous velocity with which electricity travels through a copper wire is complete evidence that ordinary matter is capable of transmitting something at a considerably greater rate of speed than the waves of light and heat. Why, then, should not appropriate kinds of matter be assumed capable of transmitting these also, and if so, the need of the interstitial presence of ether ceases altogether." With this view of the ether as molecular, we have matter pervading space which is in the strictest sense the correlative of force; for, if, with Sir William Grove, we regard "electrical phenomena as the molecular polarization of ordinary matter, acting by attraction and repulsion in a definite direction," then elementary matter, in holding potential or non-acting force, is to the senses *nil*, but in a transition state while acting dynamically; that is, to the senses creatively it evolves light, heat, and other electrical phenomena in accordance with the direction its atomic poles assume. These various motions in producing light, heat, and other correlates are exponents of the changes in the condition of the matter. Polarity, attraction, and repulsion are thus syllables in the law of creation by which matter evolves out of seeming void into visible, sensible, and finally into a ponderable form.

Chemical affinity as a creative force is, through the medium of electricity, directly convertible into other modes of motion, while electricity is itself a direct result of chemical action. The electrical and chemical force being thus convertible, any sensible manifestation of electricity would be the result of an insensible chemical action of ultimate particles, while a secondary action of either force would have different expression or result, as the action of a composite molecule would necessarily differ from the atomic movement of elements.

Grove defines force to be that which produces or resists motion. Now if matter by its inherent property of arrangement produces the motion of electricity, light, heat, etc., as in aggregated form it resists sensible motion, then matter and force produce the same results, and we are led, *a priori*, to a consideration of matter as representing force. This involves a recognition of matter in a form we are not cognizant of in ordinary condition, a form, however, which is not only conceivable, but seems amply demonstrated by Profs. Crooke, Hittorf, and Goldstein's experiments upon attenuated matter in vacuum tubes. The divisibility of matter which is there shown to be wholly indefinite, may be approximately considered by a reference to Prof. Tyndall's experiments in decomposition by light, and of the failure to detect the dimensions of "sky matter which had been growing for fifteen minutes" without acquiring size equal to the one one-hundred-thousandth of an inch, at which limit they would become microscopically visible.

Science offers no measurement of these molecular and microscopic differences; we can reach only vague estimates "that a few ounces of vapor are capable of expanding into an actinic cloud of the magnitude and luminosity of Donati's comet." While, however, it is impossible to resolve this sky matter into luminous entities by the microscope, other means of measurement are afforded by the motive power of the individual particles; the amount of which force is shown by the rate of rotation of the radiometer. Hence, through the dynamic property of this tenuous matter we reach quantitative results.

Mr. Johnston Stoney estimates the number of molecules in a cubic centimeter (one-fourteenth of a cubic inch) of air at ordinary pressure at, in round numbers, a thousand trillions, while Prof. Clerk Maxwell approximately reached nineteen million billions, for any gas at normal density. Work done by Mr. Hodges in Harvard physical laboratory indicates the thickness of film, and the consequent measurement of molecular diameter, in electrolysis of water, at about the one ten-millionth of a centimeter. Now, that each individual molecule is built up of atoms, each atom of which is endowed with activities, leads us to a review of the calculations which Faraday "is almost afraid to mention," that "the electrical force involved in the decomposition of a single grain of water amounts to eight hundred thousand discharges of a large Leyden battery, the equivalent of a great flash of lightning, while the chemical action of a single grain of water on four grains of zinc would yield a force equal to a powerful thunder storm." These estimates of the sufficiency of matter and the more newly discovered "atomic induction," or the influence which one part or parts of a molecule exert upon another, and the proofs now given of the mechanical action of light as the correlative of sound, seem to call for a reconsideration of the doctrine of imponderables and a review of the theory of matter as a mere empty capacity subject to the control of forces external to itself, of complex vortices, and an indefinite viscous medium of transmission.

If light be, in accordance with modern science, an electrical disturbance, and electricity be a material agent, which is now the growing heresy or the newly recovered truth in science, then we have light as the direct effect of the motion of this electric matter, and not of an interstitial medium. Hence, if what we have vaguely termed electric force be regarded as the activity of electric matter, "matter in a fourth or radiant state," we have in considering the atomic or elementary activity of Faraday's electrolyzed water, not only the tenuity and elasticity necessary to transmission, but the very matter and force to produce the light itself.

Faraday found "that there are many arguments in favor of the materiality of electricity and but few against it;" and even Dr. Young, in referring to a chemical analysis of electric fluid, said, "Might I be permitted such a doctrine, it should be that it consists of oxygen and hydrogen combined with caloric only." Now, extending our inquiry from the nature of the electricity producing light to the nature of the light itself, if, with Dr. Young, we confine ourselves to the radiant visible character of light, the visible property is explained by the undulations of a luminiferous ether as distinct from ordinary matter; but the other properties of light—its chemical effects, the optical prolarity of a crystal, and its dependence upon the polaric condition of its constituents, the oxidation of surfaces as the cause of natural colors, its equivalent action with electrical currents, and its mechanical correlation with sound—the undulatory theory does not explain. These facts, however, tend to show that light is not a mere mechanical radiant force propelled in space, and transmitted by a neutral medium, but an active principle or agent whose activities are similar and co ordinate with the recognized movements of fine matter in its ultimate or chemical relations.

By placing matter under the limiting circumstances of vacuum tubes, and thus making its atomic and molecular behavior appreciable, Prof. Crookes, as we have said, conceived the theory of a fourth or radiant state of matter as the result of ultra-gaseous expansion. His experiments were made with pressure reduced to the one-millionth of the atmosphere, and the results are: First, that by the reduction of pressure, the free path of the molecule is increased, and that in this long range of movement it becomes possible to consider the individual molecule. Second, that the molecular stream is driven off by repulsion from the negative pole in straight lines, and the extension of the dark space at this pole is the result of the length of the free path, and that it is only by contact or collision with other molecules at the point or limit where this repulsive force ceases that light is evolved. Third, that this radiant matter moves in straight lines. Fourth, that where intercepted it casts a shadow. Fifth, it exerts strong mechanical action where it strikes, the molecular stream from the negative pole being capable of moving solid matter; and that by making the negative pole movable, a light body receiving the impact of this attenuated matter will recoil sensibly. Sixth, that the phosphoric beam evolved is deflected by a magnet. Seventh, this radiant matter produces heat when its motion is arrested.

These experiments seem to indicate that these various results depend upon the movement of the attenuated matter itself, and that it is to the action of the residual gas independent of the presence of ether that we are to look for the production of light. That it is the motion of light particles, and not the strains of a viscous medium, which in these limited conditions become sensible.

We are here brought face to face with the opposing theories of ether undulations, and the emission theory of light, as a material agent, propelled in straight lines and propagated by contact of particle with particle.

The mechanics of light—refraction, interference, and diffraction—demand an elastic medium. This the undulatory theory supplies, but the chemistry of light, the *initial* movement, it leaves wholly unexplained. Now, in these experiments, the expanded gas itself becomes the medium of requisite tenuity and elasticity, and it is the atoms of the fine matter, as they fall pole to pole, or shiver in recoil in structural processes, which are the motors in the mechanism we are to consider.

As the mechanical effects are directly subject to and dependent upon previous chemical or atomic action, we are led first to a review of the theory of polarization. In a birefractive crystal of tourmaline a beam of light incident upon the plate is divided into two; the one vibrating parallel, the other at right angles to the axis of the crystal. "The grouping of the molecules and of the ether associated with the molecules reduces all the vibration of the incident beam to these two directions." The beam perpendicular to the axis is quenched with great rapidity by the tourmaline; the grouping of the molecules, or, in other words, the angular relations of the molecules, impedes the transmission of the beam at right angles.

This process is capable of mental presentation only by supposing that the molecules in this angular arrangement offer material barriers to the particles of light matter impinging upon them, just as the molecular structure of iodine renders it opaque to light. Hence, in the quenching of the beam, it is the axial arrangement in the matter of the crystal which coerces a transmitted beam into the two sidedness recognized by Newton. Parallel to the axis, it is transmitted; perpendicular, it is cut off, so that the light matter falling upon the atoms transversely placed is simply superposed atom upon atom, with of course the negative result of darkness. With this view the polarization of light is atomic interference—the filling up or fitting in of atom to atom—similarly, we may suppose, to the optical interferences explained by the fitting in of theoretical waves.

The undulatory theory is based upon analogy. Now, if in the summing up of analogies by the later developments of the molecular behavior of fine matter, in the breaking up of gases, the weight of analogous evidence seems to bear upon the molecular constitution of light as a gaseous material in its widest range of expansibility, then a review of phenomena with reference to their adjustment to this doctrine becomes expedient.

Prof. Crookes' experiments upon the phosphorescence of vacuum tubes offer, as we have seen, striking analogies to the mechanical action of finely diffused matter. Where intercepted it casts a shadow—is deflected by a magnet, swaying like a wand under its coercive action—it produces heat where arrested, and drives with relatively strong mechanical force a concrete body placed within range of the molecular stream.

Prof. Reynolds and others offer experiments (based upon the previous work of Prof. Graham), in the transpiration and effusion of gases through porous substance, which offer striking analogies in the behavior of gases during these pro-

cesses, and of supposed light particles when subjected to the restrictive action of a diffraction slit.

In this work, a law of fixed relations is established between the specific gravity, by which of course is meant the mean distance separating the molecules, the linear dimensions of the aperture, and the rate of pressure upon the gas. This law, he thinks, amounts to nothing less than an absolute demonstration that gas possesses a heterogeneous structure. He has extended the dynamical theory of gases so as to take into account the forces, tangential and normal, arising from varying conditions of the gases subjected to examination, and finds that he obtained not only very different results, but also different laws of motion, with a difference in the size of aperture; but that so long as a fixed ratio exists between the density of the gas and the breadth of opening in his plates, the law of motion is invariable. Thus, in a simple gas, as hydrogen, "the density of the gas is inversely proportional to the lateral dimensions of the passage through the plates." Without quoting the different mathematical formulæ given in Proc. Roy. Soc., vol. 23, p. 34, *et seq.*, for the varying conditions in transpiration and effusion dependent upon the employment of pure or mixed gases, and the passage into vacuum, or transfusion into other gases, the equations prove the fundamental law that "the density of the gas is in inverse proportion to the size of the aperture, and that the times of effusion depend upon these conditions, whatever be the cause of transpiration, *i. e.*, a difference of temperature, or a difference of pressure." Nor will space admit of a comparison of these movements, when, by increasing thickness of the plate, the opening becomes a tube, and the rates of effusion are altered by capillary resistance. It is sufficient to establish the analogies in gaseous movement, and the movement of supposed light particles, that differences exist, and that these differences may be estimated. An experiment with a mixture of hydrogen and air gave the result that the mixture obeyed neither the time of transpiration nor effusion, but passed more quickly than either. Upon analysis, however, of the gas, it was found to have changed its constitution. It contained more hydrogen and less air than the original mixture. Such a separation of mixed gases must necessarily follow as a consequence of molecular movement. Each gas is impelled by its own peculiar molecular force, which in hydrogen is about 3·8 times as great as in air. The rate of diffusibility of a gas is therefore said to be inversely as the square root of the density. But the density, we know, depends upon the molecular mobility. The degree of motion which a molecule possesses regulates the volume or the mean range of the molecule.

This movement of gases through small apertures and porous substances appears to be solely due to their own proper molecular activity. The intervening plate acts as a sieve which prevents the passage of gas in mass, and permits only the individual molecules to escape. Moreover, this movement is nearly equal, whether the gas passes into a vacuum or is transfused into another gaseous atmosphere.

[*To be continued.*]

[Continued from SUPPLEMENT 374, page 5971.]

SOME OF THE DANGEROUS PROPERTIES OF DUSTS.*

By F. A. ABEL, C.B., F.R.S., President of the Institute of Chemistry.

NUMEROUS experiments similar to those of Marreco and Morison were made by the lecturer at Wigan with mixtures of air and coal dust from Seaham and other collieries, in the complete absence of fire damp, which were passed through the apparatus at different velocities up to 1,000 feet per minute. Small cannon, especially constructed to insure uniformity in the volume of flame produced at different times, were fired in them, either singly or in pairs, in rapid succession; and exposed heaps of gun-cotton and of slow and quick-burning gunpowder were exploded in the dust-laden air. The results occasionally confirmed to some extent those of Marreco and Morison and the Chesterfield experiments. At velocities of 400 feet per minute the dust, which was either passing at the time or was raised by the concussion of a first shot, did not appear to produce any increase in the volume of flame furnished by the cannon, but a decided though inconsiderable lengthening of the flame was several times observed at higher velocities and with the employment of the most inflammable dusts. Some of these, when thickly suspended in air traveling at velocities of 500 to 1,000 feet per minute, and exposed to the action of a large flash of flame (as produced by the loose heaps of gun-cotton and *blasting* powder), exhibited a tendency not only to burn explosively in and close around the flame, but also to propagate flame, or cause it to travel along some distance; but the most decisive results of these experiments were not of a nature to warrant the conclusion that flame could be carried along indefinitely, or even to a very considerable distance, by coal dust in the complete absence of fire damp, as now maintained by Mr. Galloway. There can be no question that the scale of magnitude upon which the first ignition in the dust-laden atmosphere is produced must greatly influence the extent to which the propagation of flame in this way will extend, and Mr. Galloway's experiments at Llwynpia, therefore, were likely to develop conditions more nearly approaching those of the real state of things in a mine than experiments in galleries of smaller dimensions, and with small initiating volumes of flame. But the necessity for caution in deducing very decided conclusions from even large-scale experiments appears to be illustrated by some of Mr. Galloway's results, inasmuch as some of the great distances to which the flame extended were observed under conditions decidedly favorable to the projection of the flame by causes which would not come into play in the same way in a mine-working. The experiments made some years ago by Mr. Hall in an adit (which have already been referred to) appear to have a more direct bearing upon results likely to be actually produced underground in a dust-laden atmosphere. In those experiments, the extreme distance to which flame was carried by dust, first ignited by the flame from a very excessive charge of powder (4 lb.), was 180 feet. It is of course possible that the coal used was not of the most inflammable description, and that its fineness and density were not most favorable to its becoming very thickly suspended in air. On the other hand, Mr. Hall stated, in his evidence before the Royal Commission, that the atmosphere in the adit was only "practically" free from gas

The volume of flame from a blown out shot in a mine-working is generally considerable, but it appears that exaggerated estimates are entertained of the distance to which, *in the absence of dust*, the flame will be projected, and it is probable that the large volumes of flame, extending occasionally to many yards from the spot where the shot was fired, are in a great measure due to the ignition of dust raised by the concussion and rush of air at the instant of firing. Mr. Hall, in his experiments in the adit, found that the flame from the shot of 4 lb. of powder reached to a distance of only 18 to 21 feet when no dust was present. A few months ago that official directed the attention of the lecturer to the occurrence of two accidents in the Liverpool district, each one occasioned by a shot of 1 lb. of powder blowing out its stemming without shaking or bringing down any coal. In both instances the shot lighter and two pitmen had retired about 100 feet from the seat of the shot, that is, about 30 feet in a straight line with it, and 60 to 80 feet along both directions of a working running at right angles to the drift in the face of which the charge was fired. In the case of one accident, a man was killed, and serious injuries were sustained by the other men in both instances. There were signs of charring upon the props up to, and 5 or 6 feet beyond, where the men were standing, but they did not extend further. The drift and the level in which these accidents occurred were 5 feet high and 12 feet wide. Mr. Hall informed the lecturer that a strong impression existed among mining men on the spot that the flame of the shot, quite unaided by gas or coal dust (the latter was known to be present) would have extended so as to produce the effects described. This appeared so at variance with Mr. Hall's experiments in an underground working, and with Mr. Abel's own experience in other directions, that the latter has endeavored to obtain some precise experimental data with regard to the distance to which any burning effect from a blown out charge of 1 lb. or 1½ lb. of powder would extend in a mine-working, in the absence of dust. With this object he availed himself of the friendly assistance of Major Durnford, R. E., Instructor in Field Fortifications at the School of Military Engineering, Chatham, under whose direction Lieutenant Raban has carried out an instructive series of experiments in accordance with suggestions made by Mr. Abel as the work proceeded.

The locality selected for the first experiments formed a portion of some obsolete fortifications at Chatham, and consisted of a masonry gallery or *caponier*, 8 feet 8 inches high to the spring of the arch, and 8 feet wide below the arch, to a distance of 28 feet from the closed end; from that point it tapered on one side to 6 feet along a length of 2 feet 6 inches, and was 6 feet wide for a length of 3 feet 6 inches, up to a pier or square column 4 feet by 3 feet 6 inches; round which the gallery curved, being at this part 4 feet 2 inches wide. The straight part of the gallery, from the dead wall at one end to the projecting pier at the other, was 34 feet long. In the wall to the left of the blocked end there were six narrow loop-holes up to the curve, commencing at 18 feet from the end, and 2 feet 6 inches apart; in the opposite wall there were four commencing at the same distance and 5 feet apart. Over the wall at the blocked end of the gallery there was an opening into the outer air, and a considerable current of air passed through it along the gallery to the curved end, which led into a large narrow gallery at right angles to this wide one, and having large chambers opening into it.

In some preliminary experiments, an iron tube was let into the face of the wall at the blocked end of the gallery, so as to represent a strong blast hole, and this was charged with 1½ lb. of powder, untamped in some experiments and tamped in others; some pieces of gun-cotton were suspended from the roof of the gallery, at a distance of 28 feet and farther along, and observers were stationed outside the gallery opposite the several loop-holes. But while the pieces of gun-cotton were not inflamed, there were conflicting opinions concerning the distances at which flame was seen, probably caused by the general illumination of the gallery by the flash of the explosion. It was, moreover, found that the iron tubes containing the charges were more or less considerably torn, so that portions of the exploding charge escaped laterally. The following method of experimenting was eventually adopted: Charges of 1½ lb. and 2 lb. of powder, untamped and tamped, were fired from a small roughly bored out gun-block, the bore of which was 1 foot 9 inches long and 2¾ inches in diameter; the gun was raised so as to project the flame right along the gallery at about its center. A light wood-work frame, 5 feet square, was fitted with thirty-six cross wires 1 foot apart, so as to furnish thirty-six points of intersection; to each of these points a small tuft of gun-cotton was attached, and the target thus fitted was fixed vertically so as to face the charge, in the center of which was fixed an electric fuse. In this way small charges of gun-cotton were distributed uniformly over all parts of the target, which filled a great part of the section of the gallery. The distance of the target from the charge being gradually increased in successive experiments to 20 feet, it was found that with the employment of 1½ lb. and 2 lb. charges, untamped, in three instances out of ten experiments only one, or at most two, of the tufts of gun-cotton were inflamed, this being apparently the extreme distance to which flame, or matter sufficiently hot to inflame gun-cotton, was projected. At a distance of 19 feet, with 1½ lb. charges, two out of three shots did not inflame any of the gun-cotton tufts. With 1½ lb. charges firmly tamped, one tuft only of the thirty-six was fired, in two experiments at a distance of 20 feet, while in three others no gun-cotton was inflamed.

It appears from these results that in a gallery or mine-working of an area not very dissimilar to that in which the accidents just referred to occurred, the flame or heated gases from 1½ lb. and 2 lb. charges, fired under conditions favorable to the production of the maximum flame, and its complete projection in the direction of the discharge, only reaches occasionally, and to a very limited extent, to a distance of 20 feet. No doubt a powerful air current in a mine, passing in the direction in which the shot is fired, must have a tendency to aid the spread of the flame to a greater distance, but the difference between 20 feet and 100 feet, the flame having in the latter instance extended to a distance of 75 feet along a gallery at right angles to the point of ignition, is far too great to be only ascribable to the effect of an air current in elongating the flame. As the first of the loopholes above referred to existing in the walls of the gallery was 18 feet from the shot, they could hardly affect the distance to which the flame was found to reach.* It will be observed that these results correspond with those which Mr. Hall obtained with 4 lb. charges of powder in an adit, the dimensions of which are not specified.

No gallery of large dimensions and free from the small lateral openings was available for the continuance of these experiments, but it was thought that some experiments in subterraneous passages of much smaller dimensions (military countermines) might give instructive results. A so-called envelope gallery was therefore first selected for the purpose. This gallery was 5 feet 9 inches high to the crown of the arch, and 4 feet 9 inches to the springing of the arch, and only 2 feet wide. The part selected for the position of the gun and the target was straight, but the portion immediately beyond was curved. In rear of the gun, the gallery was quite open to a considerable distance. One and a half pound charges, untamped, were fired, and a frame target the width of the gallery and 4 feet 6 inches high, constructed so as to give 15 points for the attachment of gun-cotton tufts, was placed at gradually decreasing distances from the gun, commencing at 20 feet. Even at a distance of only 14 feet from the charge none of the gun-cotton tufts was inflamed; but the target was blown forward about 12 feet and partly broken. It was evident that the fact of the gallery being open at the *rear* of the charge greatly reduced the tendency to the projection of flame to a distance in the direction of the explosion. The resistance opposed to the movement of the air by the curvature of this very narrow gallery, a short distance in front of the seat of the experiments, may have also contributed to diminish the distance to which the flame or highly heated gases would extend. When the experiments were continued in another gallery, of the same dimensions but straight and terminating in a head, like a drift in a mine, the cannon being placed close up to the face of the drift, several of the tufts of gun-cotton were inflamed at a distance of 27 feet; one was inflamed when the target was 30 feet off, and one also at a distance of 32 feet, but none were ignited at a distance of 35 feet from the charges. Here, then, in a long gallery, narrow in proportion to its height, but in all respects representing a drift way in the mine, the distance to which the flame of a blown out shot of 1½ lb. of powder extended was less than 35 feet, and therefore considerably less than one-half the distance from the seat of the blown out shot of 1 lb. of powder where the men were burned, in both directions in the cross-workings, in the accident above cited. The influence of coal dust in increasing the distance to which the flame from a blown out shot will extend in mine workings is therefore conclusively demonstrated by a comparison of the effects of those accidents with the foregoing experimental data. On the other hand, the important circumstance noticed by Mr. Hall, that no signs of burning on the props in the mine were visible at greater distances than a yard or two beyond the spots where the men were waiting, although there were open workings in both directions for some considerable distance, and although the flame was sufficiently extensive at those spots to injure the men severely, proved conclusively that coal dust had not the power, in these two instances, to carry on the flame to a great distance from the source of fire. Had there been any gas in the air of the mine, the flame would doubtless have extended much farther, and perhaps throughout the adjacent workings The amount of dust raised by the blown out shots may, however, have been less considerable than in other similar occurrences, and the dust itself may not have been so highly inflammable, or otherwise of so suitable a character for carrying on flame, as that existing in other mines where undoubtedly dust has played an important part in enhancing the magnitude of explosions. At any rate these results demonstrate the necessity for the exercise of caution in drawing conclusions of too sweeping a nature with regard to the causes and extent of such coal mine explosions as cannot be quite clearly ascribed to fire-damp. A few experiments have been made, in the largest gallery (caponier) at Chatham, to test the power of coal dust to carry on the flame from a blown out shot. A large quantity of very fine inflammable coal dust from Seaham Collieries was suspended in the air by employment of sufficient mechanical contrivances, and clouds of the same dust were also blown into the gallery in the direction of the shot, and immediately in front of it, just when it was fired. One of the flame-screens was placed across the gallery where the pier jutted out (at a distance of 34 feet from the shot), and pieces of gun-cotton were attached to nails driven in the wall along the short narrow part of the straight gallery and to some distance round the curve. In every one of the experiments tried (three) with 1½ lb. of powder, fired when dust was thickly suspended and carried along in the air, the flame burned a number of pieces of gun cotton on the screen; in two experiments gun-cotton was burned at a further distance of 1 foot 6 inches, but not beyond; in the third, some flame traveled to the end of the straight gallery, and to a distance of 4 feet 8 inches beyond the curve, but gun-cotton was not inflamed beyond that point. In this case, therefore, flame reached rather more than, and in the others not quite, double the distance with dust thickly suspended in the air, to what it did in the absence of dust. Experiments will be continued in the long narrow galleries which have been spoken of.

It must now be accepted as beyond question that very few, if any, explosions have occurred of which the destructive effects, so far as burning and production of the fatal after-damp are concerned, have not been more or less considerably increased through the agency of the coal dust raised by the explosion, and that the latter has been in very many cases instrumental in causing the burning effects of the explosion to spread over great areas, and to reach to workings which, in the absence of dust, would have escaped the visitation. Even of late years, long since the observations of Faraday and Lyell have been confirmed and extended, mining engineers and others immediately connected with the working of coal mines have been very prone to ascribe explosions, which did not admit of satisfactory explanation by an accidental failure of ventilation or other evident causes, to the sudden disengagement or outbursts of fire-damp, such as are, in fiery coal seams, of no uncommon occurrence, and sometimes very serious in their magnitude and long continuance, and to charge such sudden escapes of gas into some part of the mine-workings with the whole extent of the disaster, rather than to credit coal dust with any important share in the origination or even in the extension of the explosion. In many instances the occurrence of such outbursts, following upon falls of roofs or the firing of shots, or the rapid disengagement of fire-damp from coal or goaves, consequent upon sudden changes in atmospheric pressure, have been clearly proved to have preceded disastrous explosions. In others, however, the conclusion that an explosion has been connected with the occurrence of a sudden disengagement of gas in considerable volume has been based upon assumptions or conjectures, more or less admissible, or upon evidence of doubtful nature collected after the explosion (as in the case of the recent explosion at Seaham Collieries). Under any such circumstance, however, it is, to say the least, extremely difficult to realize how sufficient gas to produce an explosive atmospere can be conveyed, even by the most powerful ventilating currents which can circulate in mines, from the seat of such a sudden outburst to far distant portions of the mine to which the actual explosion is proved to have extended,

* A lecture delivered at the Royal Institution of Great Britain, Friday, April 28, 1882.

* The closing up of these was not found to affect the results.

within the period which is known, or believed, to have intervened between the first disengagement of the gas and the firing of the explosive atmosphere produced thereby *in the vicinity* of the outburst, by the firing of a shot, by a defective lamp, or by other means of ignition. On the other hand, the character of the effects which in many instances have been produced by the explosion, the evidences of severe burning, such as could not be produced by the rapid explosion of a gas mixture only, and the deposition of partially burned or coked dust in very distant and distinct parts of the mine workings, leave no room for doubt that coal dust has played a more or less important part in almost all the explosions which have been of late submitted to investigation. Further, it must be conceded that in some instances coal dust would indeed appear to have been the chief instrument of destruction.

To sum up: it has not been difficult, as will have been seen from the foregoing, to demonstrate experimentally that the existence of a very small proportion of fire-damp in the air of a mine may determine the propagation of flame by coal dust, ignited by the explosion of some local accumulation of a gas mixture, or by the inflammation of gas suddenly disengaged, or even by the flash from a blown-out shot. It has also been clearly established that in so-called fiery mines the air is never likely to be actually free from fire-damp, and that as much as 2 per cent. may exist in the return air of a very efficiently ventilated mine of that class. It must therefore be regarded as a thoroughly well-grounded conclusion that, in many disastrous explosions, coal dust is the chief agent of destruction, and it is indisputable that but few explosions occur of which the effects have not been more or less considerably extended and aggravated by the coal dust which is raised by the fire damp explosion. It may also be admitted as not improbable that in some instances the influence of dust may, apart from its combustibility (as described), determine the ignition of a mixture of air and dust with a small proportion of fire damp by the flame which a blown-out shot or the accidental ignition of some local accumulation of explosive gas mixture, has produced. Lastly, it is conceivable, as contended by Freire Marreco, Galloway, and some Continental observers, that a mixture of an inflammable coal dust and air may even in the complete absence of fire damp, both originate and carry on to some distance explosions which, though much inferior in violence to those developed through the agency of gas mixtures, will be at least equal to them in regard to the disastrous effects on the lives of those exposed to them. That mixtures of coal dust and air alone may have the power to carry on the explosion originally caused and disseminated by a gas, air, and dust mixture into regions where no gas whatever exists, will now be generally admitted. The great disturbance of the air which must proceed in immediate advance of the rush of flame produced by the ignition of a mixture of gas and air charged with coal dust will, in many mine-workings, raise a dense cloud immediately in front of the flame, and the latter will thus be fed as it advances. Mr. Galloway concludes, as the final result of his experiments with coal dust, that the presence of fire damp is altogether unnecessary to *bring about* a coal-mine explosion; but, admitting that the result of certain experiments may seem to favor this conclusion, its realization necessitates the fulfillment of conditions which cannot but be very exceptional, and its acceptance is certainly unnecessary to add to the formidable character of coal dust as a source of danger and an agent of destruction in mines.

Whether an explosion originates with, or is chiefly caused by, the production of a mixture of fire damp with air in such proportions as to be more or less rapidly and violently explosive; whether the originating cause be the reciprocal influence of a small proportion of fire damp and of coal dust (or dust of other descriptions of minerals occurring in coal-mines) coexisting in the air of a mine; whether, possibly, it simply originates with a mixture of very inflammable coal dust and air in the complete absence of fire damp; or whether, lastly, only the very limited concession be made that coal dust will add to the extent, and increase the burning effect, of a fire damp explosion; in any case, the existence of dust in abundance, and in a dry state, in coal-mine workings, must be recognized as a source of danger not greatly inferior to that caused by local accumulations, or the accidental liberation, of fire damp. The possibility of dealing with the source of danger should therefore be as much an object of earnest work as has been the improvement of ventilating arrangements for mines.

It being generally impracticable effectually to deal, by actual removal, with the continual accumulation of dust in mine workings, the only available method of diminishing the dangers arising from its constant production appears to be that of maintaining the floor in the roads, etc., in a damp condition by efficient watering arrangements, almost continually applied. The high temperature of the mine, in many instances, must often render this a difficult and costly process, on account of the rapidity with which the water will evaporate; hence attempts have been made to apply hygroscopic substances (such as calcium chloride, sea salt, or rock salt) in conjunction with water, or to use brine, with a view to retard its evaporation, and some successful results appear to have recently attended their application in several districts. In some instances, with improved appliances for the uniform and periodical distribution of sufficient water, the maintenance of mine roads in a sufficiently damp condition to prevent dust from being raised in any considerable quantity appears to have been accomplished with fair success. There are, however, localities where it is almost impracticable to maintain the floor of the roads in a damp condition, in consequence of the great increase thereby of the tendency to their being gradually raised by the pressure to which they are subject.

Apart from the effects of dust in augmenting the disastrous results of such fire damp explosions as may arise from the existence of a defective, or an open, safety lamp in the vicinity of an accumulation of gas, or of a locality where a sudden outburst of gas occurs, the *blasting* of coal or of rock, in those parts of a mine where fire damp may exist, if even only in very small quantities, constitutes the chief source of accidents in which coal dust may have played an important share. There is no doubt, therefore, that the elaboration of really safe methods of getting coal in places where blasting by powder is now resorted to, and of removing the harder rock in the working of drifts where fire damp may exist, will most importantly contribute toward the diminution of danger arising from the accumulation of dust in mines. The substitution of efficient coal cutting machines for blasting may to some extent supplant the use of powder, and the employment of compressed air as an agent for bringing down coal or rock has been made the subject of ingenious contrivances, which appear, however, as yet, to labor under some disadvantages in regard to cost, facility of use, and general efficiency. Attempts have been made to render the employment of powder in the presence of fire damp safe, by using it in conjunction with water. In the first instance it was proposed by Dr. Macnab to bring the latter into direct operation as the cleaving or blasting agent by inserting a cylinder containing water into the blast hole, and connecting it with a very strong external vessel, in which the powder charge was fired, much as the powder charge is fired in the powder chamber of a gun, the generating gas being brought to bear upon the confined column of water, and causing the latter to exert a rending force upon the coal by which it was surrounded. As the results furnished by this method of operation were not promising, the comparatively very simple expedient was resorted to by Dr. Macnab of employing water simply as tamping in a charge hole, a cylinder containing the liquid and of suitable length to fill the hole being inserted over the charge of powder. In the event of a charge blowing out, the dispersion of the water in a very finely divided condition was relied upon to effect the extinction of the volume of flame which, under these conditions, would be projected into the air of the mine. Some carefully conducted experiments, with blast holes charged by this method and surrounded by an explosive gas mixture, showed that occasionally no ignition of the gas resulted from the blowing out of the shot, but that in most instances, the conditions of the experiments being the same, the gas mixture in front of the blast hole was exploded when the shot blew out. It is possible that a careful regulation of the charge and length of tamping may render this mode of operation a comparatively safe one, though it may be doubtful whether absolute reliance could be placed upon the invariable extinction of flame in the case of blown out charges. When the attention of the Royal Commission was directed to the subject of the dangers attending the employment of explosives in coal mines, it occurred to Mr. Abel to attempt the application to the getting of coal of the principle which he developed some years ago, in the course of his researches on explosive agents, namely, the sudden transmission in all directions of the force exerted instantaneously by a *detonation*, by surrounding the detonating charge with water. It was found in a large number of experiments that when comparatively small charges of gun-cotton or dynamite (the latter being preferable) were inclosed in cylinders of light metal or paper filled with water, and occupying the entire available space (or nearly so) in a blast hole, the detonation of the charge in holes of excessive strength, when employed in proper proportion to the amount of water by which it was surrounded, was always accomplished without ignition of the explosive gas mixture with which the opening of the blast hole was surrounded. The interesting fact was, moreover, established, by operations carried out in hard coal in Lancashire, that the action of the detonating charge is modified to great advantage by inclosing the envelope in a long column of water. Instead of exerting a powerfully crushing or disintegrating action, confined within comparatively narrow limits, whereby a charge of gun-cotton or dynamite is rendered of little value as a means of getting coal when used in the ordinary way, the distribution of the explosive force in all directions by the column of water causes it to exert a cleaving or splitting action even superior to that exercised by ordinary blasting powder. The further development of this method of applying detonating agents to blasting purposes in coal mine workings appears, therefore, well worthy of attention.

Another method of getting coal, which, though not new in itself, has been applied in a novel manner and with most promising results by Messrs. Smith & Moore, has the great advantage of dispensing entirely with the use of explosive agents, and of any but the most simple mechanical appliances.

It consists in applying the force which quicklime will develop if confined, and made to combine under that condition with water, whereby it undergoes very considerable expansion, a large amount of heat being at the same time developed. Messrs. Smith & Moore convert the freshly burned and crushed quicklime into very compact cylindrical masses, or cartridges, having a small groove on one side, so that when the requisite number of cylinders are inserted symmetrically into the mechanically drilled hole in the coal, which they fit accurately, a narrow pipe, with perforations along its entire length, inclosed in a tight fitting stocking of spent webbing, and provided with a stopcock, may be inserted into the side of the charge, which is afterward tamped in the usual manner. The proportion of water necessary to slake the lime, *plus* an excess of about one-sixth, is then forced into the hole through the pipe by means of a simple hand syringe, and the stopcock of the pipe being closed, the operation is complete. In a brief space of time sounds indicative of the cracking of the mass of coal which contains the cartridge show that the expansion of the lime by its union with the water, and the very considerable development of steam within the cartridges, are performing their work, and after an interval of time varying with the strength of the part of the seam operated upon, the coal is detached in large blocks. The holes can be charged so rapidly that a considerable number may be put into operation in quick succession by one or two men.* As the action of the charge occupies some little time (fifteen or twenty minutes), they really come into operation together, and in this way large faces of hard coal, in long wall workings, are brought down with ease and certainty. Whether these compressed lime cartridges can be applied with any success in stone still remains to be determined, but in point of cost, simplicity, and above all safety, this method of detaching coal appears to rank before any other yet tried. Besides entirely avoiding the use and production of flame or fire in the blasting of the coal, the operation is conducted gradually and almost noiselessly, and the raising of dust by the more or less violent concussions which attend the employment of explosives in any form or manner is avoided.

It is insisted upon by a great majority of those most competent to judge, that the employment of explosives cannot be dispensed with in the profitable working of coal mines. That the use of gunpowder in the ordinary way, even with strict attention to all practicable precautions, is a most prolific source of accident, has long been recognized. The development of safe methods of applying explosive agents, or of simple and effective substitutes for them, is therefore of such paramount importance in securing protection to the miner against the dangers of fire damp and of coal dust, that those who are intrusted with the management of coal mines should spare no exertions to test rigorously but fairly the merits of any proposals which afford promise of success in this direction.

* In one of several operations of this kind recently witnessed by the lecturer at Shipley Collieries, Derby, in the "deep hard seam," which is nearly 3 ft. thick, ten shots were fired (*i. e.*, watered) together, bringing down a block of coal 39 ft. long by 3 ft. thick and 2 ft 10 in. high, weighing about 10 tons. The average time occupied in boring a hole (by mechanical drill), charging and tamping it, and watering the charge, was twenty minutes. The usual operation of bringing down this very hard coal, by wedging, is exceedingly slow and laborious.

STARCH-SUGAR.

A NEW METHOD FOR REFINING AND CRYSTALLIZING STARCH-SUGAR.

By DR. FRANK SOXHLET, OF MUNICH, GERMANY.

THE improvement consists in the preparation of pure anhydrated starch-sugar (C_6, H_{12}, O_6) possessing a crystalline structure. The discoverer writes:

"Starch-sugar manufactured by the old process contains a large amount of water, corresponding to water of crystallization, and which is necessary for crystallization (viz., 9·09 per cent.); also in every 100 parts 20 to 30 parts of uncrystallizable and unfermentable substances of a gummy nature.

"The removal of these substances, which inclose the sugar particles in the form of sirup, and the preparation therefrom of pure granulated starch-sugar, is the aim of my discovery. A solution of starch-sugar, prepared in the ordinary way by the action of hot dilute acids upon starch, is concentrated in a vacuum to the consistency of a thick paste. The sirup so obtained is heated to a temperature of 70° Celsius, and then intimately mixed with methylic alcohol in closed vessels. The amount of alcohol to be used depends upon the purity of the starch-sugar and the quality of the product wished to be obtained.

"If starch-sugar contains 20 to 30 per cent. of other substances that are not sugar, there should be used 70 to 80 parts of alcohol to every 100 parts of sirup, and allowed to crystallize in closed vessels at a temperature from 30° to 40° Celsius, which may be hastened by the addition of anhydrated starch-sugar.

"The granulated mass can be deprived of its water by means of centrifugal force or a press machine.

"Granulated porous starch-sugar, in compact and well defined blocks, having the appearance of refined sugar, can be prepared by the following process:

"A clear and colorless solution of starch-sugar, on being freed from all foreign impurities, is concentrated in a vacuum to the above mentioned consistency.

"The sirup must be as clear as water; should it show signs to remain slightly cloudy in crystallizing, which very often occurs when the process of evaporation progresses too slowly or is interrupted in any way, it would not be suited for the following process, on account of the formation of water of crystallization. In this case 100 parts by weight of clear sirup is heated to a temperature of about 70° Celsius, and mixed with 10 to 25 parts by weight of boiling hot pure methylic alcohol, until the mixture is of an equally sirupy consistency. It is then placed, while hot, into tightly closed conically-shaped vessels, and allowed to cool gradually until it recedes to 30° to 35° Celsius, where it is kept until the crystallization is complete, which requires from two to three days, at the end of which time the remaining liquid is to be drawn off.

"If it is desired to obtain the crystals of sugar in a dense form, one proceeds, after removing any superfluous liquid, to saturate the porous mass once or twice with a mixture composed of 80 to 100 parts of methylic alcohol and 100 parts of concentrated sirup, and allow the crystallization to take place at the ordinary temperature.

"When the required density is reached, the liquid part is removed and the crystals of sugar washed with methylic alcohol; 5 per cent. of the latter to the entire weight of the sugar mass should be sufficient. It is afterward freed entirely from methylic alcohol by distillation in a vacuum pan, starting at a temperature of 30° Celsius, and gradually increasing it from 50° to 60° Celsius, at which point the greater quantity of the alcohol is distilled.

"If the mass of sugar is kept at this temperature for several hours in an air vacuum, it would be impossible to detect, either by the smell or taste, the presence of the slightest traces of any alcohol.

"The drawn-off liquid residue is distilled either in an air vacuum or by the ordinary way, in order to regain a portion of the methylic alcohol used, so that by this last operation the loss amounts to only 2 to 2½ per cent."

A NEW ORGANIC SUBSTANCE SENSITIVE TO LIGHT.

IT is seldom that a substance is discovered nowadays highly sensitive to light, although, no doubt, many exist in organic chemistry whose photographic properties are overlooked by the chemist.

A recent example is anthracene, which behaves in a most remarkable manner in the presence of light. This hydrocarbon, whose formula is $C_{14}H_{10}$, presents the strange phenomenon that, after exposure to light, its chemical and physical properties change, while its composition remains unaltered. For instance, if a cold, saturated, and clear solution of anthracene in benzole is exposed to direct sunlight, the solution becomes turbid, and crystals are separated; these latter are much more difficult of solution than anthracene, while they melt at a much higher temperature. Thus, anthracene becomes fluid at 214° C., while the crystals in question are not liquefied until a temperature of 244° is reached. Moreover, after acted upon by light, the resulting body is not so easily affected by reagents—such as nitric acid or bromine—which act quickly upon anthracene.

The composition of the photogenic substance is also $C_{14}H_{10}$, and for this reason it is isomeric, or, rather, polymeric with anthracene, and termed Paranthracene. The most singular property of Paranthracene is exhibited on melting; the substance then changes back again into ordinary anthracene, with a melting point of 214° C., and exhibits all the other qualities of the hydrocarbon.

It is most likely that the action of the light consists in bringing about a loose combination of several anthracene molecules into a bigger group, the crystals of the Paranthracene consisting of such molecular groups.

A phenomenon still more surprising than that just described was observed a short time ago by Fittig. When experimenting with isatropa acid,* he discovered an acid containing sulphur of the formula $C_{16}H_{12}SO_3$, or $C_{16}H_{11}SO_3H$, which he describes as a very stable powder insoluble in water. The sodium salt, as also the other salts, exhibited a most singular behavior. The clear aqueous solution becomes turbid after a very little while, and a thick white precipitate is separated. The sensitiveness to light of this sulphur salt is so great that it is almost impossible to keep solutions of the same in an ordinary laboratory for even a short time. In direct sunlight its decomposition is so rapid that freshly prepared clear solutions made with sodium or barium salts become milky almost immediately, and after a few minutes are filled with a thick flocculent precipitate.

The chemical change which here takes place is a very

* Liebig's Annalen, vol. 206, p. 34.

simple one. In the sodium salt, under the action of light, there is a splitting up of soda:

$$C_{18}H_{11}SO_3Na = C_{18}H_{10}SO_2 + NaOH.$$

The product therefore contains one molecule of water less than before.

Unfortunately, this interesting body is a very costly substance, but it would be of great interest to study more closely its photochemical character; for instance, it would be well to discover what portion of the spectrum more especially brings about the change.

The well known work of Bunsen and Roscoe upon the behavior of chlorine and hydrogen might easily be repeated, *mutatis mutandis*, upon this photogenic substance, as the resulting product of decomposition is a stable body; it would be well worth while to discover if, in the present case, the same or similar rules obtain, which the above chemists have shown to exist with mixtures of chlorine and hydrogen.—*Photographic News*.

LIME JUICE; ITS PROPERTIES AND USES.*

By MICHAEL CONROY, F.C.S.

LIME juice is the expressed juice of the fruit of *Citrus limetta*, a member of the orange tribe (Aurantiaceæ). The tree is a thorny, bushy evergreen, with handsome dark foliage of exquisite fragrance. The flowers are white, resembling orange blossoms, and their perfume is equally delicious. The tree flourishes best in a light sandy soil near the sea, and comes into full bearing in about seven years after the seed is set. It grows wild in nearly all tropical countries, but is now largely cultivated in the island of Montserrat. The fruit is about one-half the size of the lemon, with a smoother and thinner rind, oval, rounded at the extremities, and of a pale yellow or greenish-yellow color. The exterior of the rind possesses a fragrant odor, and a warm, aromatic, slightly bitter taste, somewhat similar to that of the lemon. The juice, when fresh and sound, is sharply acid, with a peculiar refreshing and grateful flavor. In Montserrat the lime fruit harvest is heaviest from September to January, but a good supply of fruit is yielded throughout the whole year. Here, where the lime tree is specially cultivated for the sake of the juice, the work is done in a systematic manner with suitable machinery. The fruit, after collection, is taken to two central factories, where it is sliced by water power, and then squeezed in huge wooden presses, the juice being run into puncheons and quickly bunged up. This is a most important point in preparing the juice in a tropical climate, for if left exposed it would rapidly decompose. I am also informed that the choice fruit is alone used, and that only about two-thirds of the juice is pressed out, thus insuring greater freedom from mucilaginous and pulpy matter. The further pressings, together with the juice of the unsound fruit, are evaporated to the consistence of treacle, and sent over to this country for the manufacture of citric acid.

It is chiefly owing to these precautions that Montserrat lime juice is so much superior to that produced in Jamaica and elsewhere, where no care or supervision is exercised in its preparation.

Lime juice contains citric acid, gum, sugar, albumen, extractive matter, inorganic salts, and water. The most important constituent is the citric acid, but as to the percentage of citric acid contained in juice authorities disagree considerably. Upon this point, however, I am in a position to speak with great confidence, as during the last few years I have estimated the citricity of over 4,000 samples of Montserrat juice, each sample representing a puncheon of over 100 gallons, and having been taken from the puncheon on the quay after landing. The citricity was estimated by the volumetric process with solution of caustic soda, made of such strength that 1,000 grain measures represented 100 grains of citric acid; 7·84 per cent. is the average citricity of 4,160 puncheons, equal to about 450,000 gallons.

Lime juice contains only a mere trace of sugar, while the quantity of gum and albumen is much less than that contained in lemon juice, on which account it is much less liable to fermentation and decomposition than the latter. The quantity of inorganic salts contained in lime juice is about the same, and is also of the same nature as is obtained from lemon juice. The ash obtained from ten samples gave an average of 0·43 per cent. of the juice.

During the last decade lime juice has become a most popular temperance beverage, chiefly in the form of cordial, but its chief use is that of an antiscorbutic on board ship, and while on this point I wish to draw your attention to the following extract taken from an excellent editorial, which appeared in the *Pharmaceutical Journal* of June 3, 1871, and which contains two most important questions, that I trust will be answered in this paper. After treating of the prevalence of scurvy previous to the passing of the Merchant Shipping Act of 1867, the article says:

"There can be no reasonable doubt that this system has succeeded remarkably well, as it has secured a proper supply of good juice to the mercantile marine, and scurvy has in consequence diminished from 60 to 70 per cent. But there are two unsettled and very important questions in connection with this subject which pharmacists should be specially able to aid in deciding. (1.) The exact analytical standard of lime and lemon juice. (2.) Does genuine lime and lemon juice require the addition of alcohol for its proper conservation?"

The first, so far as lime juice is concerned, I think is answered by the tables above quoted, and with the second we shall now deal. Some eighteen months ago, I mixed together over one hundred pint samples of lime juice, representing an entire consignment from Montserrat, and divided the bulk into two equal parts. One part was filtered perfectly bright and bottled off into wine bottles, while the other half was simply strained through muslin before bottling, no preservative whatever being added to either. The samples, on the date they were bottled, were tested for citricity and gave 8·15 per cent. free citric acid. They were then put away in a spare corner of the laboratory, exposed to light, and occasionally to the direct rays of the sun for six months, when they were again examined (one from each group), with the following result:

Filtered sample, 7·95 per cent. free citric acid.
Unfiltered sample, 8·15 per cent. "

At the end of twelve months from the date of bottling, another sample from each group was examined and was found to test exactly the same citricity as when last tried, namely, 7·95 and 8·15 per cent. respectively. From this it will be seen that while the unfiltered sample retained its full citricity for twelve months, the filtered sample lost only 0·2 per cent.

This experiment, though put in hand for a different purpose, of which I will presently speak, answers the question as to whether alcohol is necessary for the preservation of lime juice, and when I state that in addition to the above test the juice was as sweet and sound as when first bottled, it will be admitted that the only answer is—No.

With lemon juice, however, the answer is the reverse, and I shall go further and show you that the quantity of spirit added by the Board of Trade regulations is insufficient and useless for its preservation. Lemon juice, owing to the fact that it contains much more sugar and mucilage than lime juice, is more liable to fermentation, and in commerce it is always, or nearly always, found in a state of fermentation, and in this state it is passed by the Somerset House authorities, and sent into bond to be fortified and bottled for the merchant marine service. In bond 15 *per cent. of proof spirit* is added to it, and this is expected not only to kill the fermentive germs, but to preserve it from further deterioration. As practical chemists and pharmacists I need scarcely tell you that to obtain the desired result double the quantity should be used. What percentage of alcohol do we add to our freshly pressed juices of dandelion, hemlock, broom, foxglove, henbane, etc.? Twenty-five per cent. at fifty-six over proof, which is equal to 39 per cent. at proof strength, and this quantity we only consider sufficient for the proper conservation of freshly pressed juices, quite free from fermentation. I have frequently seen bottles of lemon juice bursting in bond during hot summer weather, an hour or two after bottling, from the pressure of carbonic acid gas produced by the fermentation, and frequently cases have to be unpacked to replace bottles that have burst from the same cause, *in bond*. From this it is evident that lemon juice requires to be more strongly fortified, and my experience is that fully 30 per cent. of proof spirit, or better still, its equivalent of a stronger spirit, would be necessary.

I said that the experiment with the filtered and the unfiltered lime juice to which I have already alluded, was put in hand for a different purpose than that of ascertaining whether or not the addition of alcohol was necessary for its preservation. The object in view was to ascertain whether the clarification of the juice was in any way detrimental to its keeping properties, and I was led to try the experiment by observing that clarified juice sooner became darker in color, and sooner lost its fresh aroma than the unclarified, and the result showed that my suspicions were correct, though to a less extent than expected, for as already stated the clarified sample lost only 0·2 per cent. in citricity, while the unclarified sample remained intact at the end of twelve months. Why is this? To answer the question it is necessary to remember that in pressing lime or lemon juice many of the essential oil vessels of the rind are ruptured, and the oil thus escaping becomes to a considerable extent emulsified by the mucilage and sugar of the juice, thus acting as an antiseptic preservative to the juice.

It is chiefly owing to the presence of essential oil, thus emulsified, that the turbid appearance of fresh lime and lemon juice is due, and to my mind it is quite a mistake to insist upon juice being quite clear for ship use, since the filtration necessary to attain this would separate almost the whole of the essential oil, the presence of which adds so much to its keeping properties.

As already mentioned, the chief use of lime juice is as a preventive and remedy for scurvy, and in the Royal Navy only lime juice is used, with the gratifying result that the once dreadful disease is practically unknown. In the merchant marine service, however, lemon juice is chiefly used, owing to its cheapness, and here cases of scurvy are frequently occurring. It is not, in my opinion, because lemon juice is inferior to lime juice as an antiscorbutic that this result is due, but simply to the fact that it soon becomes inert and useless by fermentation, as already shown.

Lime juice has become a therapeutic agent of so much importance since the publication of our present Pharmacopœia that its introduction into the next issue is almost a certainty, and in anticipation of such a result I would recommend that the test for citricity be fixed at not less than 7·25 per cent. of free citric acid.—*Pharmaceutical Journal*.

* Read at a meeting of the Liverpool Chemists' Association.

THE CIVILIZED AND UNCIVILIZED WOMAN IN LABOR.

THE remark of Carlyle that science originated from a belief of man "that there was something wrong," has certainly received confirmation in the literature of the science of obstetrics.

The blessings of civilization, with its attending comforts and advantages, so much coveted by mankind, has its reverse side of horrors, the worst aspect of which is seen in the present physical condition of women.

It is fortunate for the peace of mind of the stronger sex that a veil is drawn before the portals of a room in which woman fulfills her duties of maternity. Could the experience of the gynecologist and the accoucheur be known to the general public, few would face the consequences of married life.

The agony endured by women during natural labor is sufficient to account for the biblical belief that such torments are the result of a special curse of God. But what are these human pains to those involved when complications exist, beginning with the forceps and ending in the classic Cæsarean operation, as now performed in Germany without anæsthetics?

Turning from the richly furnished room of the fashionable mother, in which all the resources of civilization have been gathered to ward off the effects of luxury and ease, resulting often in the necessity of making an abdominal section, and thus releasing the child, let us turn to barbaric life and observe how perfectly and painlessly the act of the reproduction of the species is performed. Lieutenant Bove, speaking of his experiences among the Jagan tribe of Terra del Fuego, says: "When the great moment arrives, the future mother leaves her wigwam, accompanied by a few female friends, and seeks a secure retreat in the woods. The very next day the young mother is often seen fishing in a canoe, or gathering shell-fish along the coast." These women marry young and are very prolific; seven, and even eight, being the average number of children.

Lieutenant Bove states that the Fuegian women lead a hard life, and are treated as slaves; but hard work, a scant diet, and plenty of fresh air seem to result in the production of small new-born children; hence the ease of childbirth. On the contrary, luxury, ease, gluttony, and other evils of fashionable life appear to effect an over-development of the fœtus; this, combined with a weak and debilitated body, may help to explain those complications in child-bearing which are so often witnessed among civilized women.—*Medical Record*.

BACTERIA IN THE SOIL AND THE AIR.

IN the laboratory of Montsouris, a series of observations has for some years been conducted on the bacterial germs present in the atmosphere and the soil, with especial reference to their relation to the spread of infectious diseases. Experiments were also made on the cultivation of bacteria in artificially prepared nutrient fluids.

The quantity of bacterial germs in the air varies with the time of year, with subordinate temporary fluctuations. It is also largely dependent on the weather, rain clearing the air to a large extent of the germs. While rain is actually falling the number of germs in the air is greatly reduced; it increases as the ground dries, and again diminishes when the drought has lasted for ten or fifteen days.

The following are the artificial nutrient fluids chiefly employed, with the means used for sterilizing them, and the degree to which they are then susceptible to the attacks of bacteria:

Fluid.	Mode of sterilizing.	Degree of susceptibility.
Cohn's nutrient fluid...	Heat of 100° C.	0·05
White of egg....	Pasteur's gypsum filter, cold.	0·22
Normal urine..........	Pasteur's gypsum filter, cold.	0·40
Normal urine..........	Heat of 110°.	0·50
Neutralized urine......	Gypsum filter, cold.	0·90
Neutralized bouillon...	Heat of 110°.	1·00
Normal urine, diluted..	Gypsum filter, cold.	1·80
Serum of blood, diluted.	Gypsum filter, cold.	6·00
Juice of strawberry and grape............ ...	Gypsum filter, cold.	9·50
Juice of cabbage, diluted..................	Gypsum filter, cold.	10·90
Juice of calf's flesh.....	Gypsum filter, cold.	13·50

The kind of bacteria varied with the different fluids; but in the two years there was found an average of from 65 to 79 per cent. of micrococcus, 14 to 24 per cent. bacillus, and 7 to 8 per cent. bacterium. In the fluids obtained from plants the bacterium amounted to about one-third.

Experiments made at the same time and in the same way in Paris (at the Mairie of the 4th Arrondissement) showed a very much larger quantity of bacterial germs in the air. The following are the numbers from October, 1880, to September, 1881:

	Paris.	Montsouris.
October..........................	920	142
November.	750	106
December...............	540	49
January..........................	470	45
February.........................	330	81
March	750	74
April............................	970	48
May..............................	1000	80
June.............................	1540	92
July.............................	1400	190
August	960	111
September	990	105

With some variations, curves formed for the two places would nearly agree, the average at Paris being about ten times that at Montsouris. More exact curves, made for weekly periods, showed a still closer coincidence in the increase and decrease at the two places. The proportion of different forms was 93 per cent. micrococcus, 5 per cent. bacillus, 2 per cent. bacterium. Ammoniacal or urine ferments were also found in the air, and are probably a fruitful cause of infectious diseases. Pierre Miquel distinguishes three kinds of urine ferments: *Micrococcus uræ*, *Bacillus uræ*, and *Torula uræ*.

The number of bacterial germs found in the air of hospitals was enormous, amounting in the Hotel-Dieu to 5,600 per cubic meter in the summer months. The following are the numbers for different months:

	Men's ward.	Women's ward.	In the city of Paris.
March, 1881............	11,000	10,700	750
April	10,000	10,200	970
May.....................	10.000	11,400	1,000
June........	4,500	5,700	1,540
July........	5,800	7,000	1,400
August	5,540	6,600	960
September	10,560	8,400	990
October.................	12,400	12,700	1,070
November...............	15,000	15,600	870

The diminution in the summer months Miquel attributes entirely to the better ventilation. The presence of hospitals in large towns he believes to be a most prolific cause of infectious diseases, such as small pox, scarlet fever, diphtheritis, erysipelas, typhus, etc.

A very interesting comparison is drawn between the presence of bacteria in the air and the prevalence of infectious complaints. The weekly bacterial curves of Paris and the weekly curves of mortality published in the "Bulletin de Statistique Municipale," under the authority of M. Bertillon, show an almost complete agreement.

Another series of observations was devoted to the bacteria present in the soil. A gramme of earth at the Observatory at Montsouris contained 750,000 germs; in the Rue de Rennes, 1,300,000; in the Rue Monge, 2,100,000.

THE TRADE IN QUININE.

FROM inquiries made by the *World* among the leading dealers in quinine touching the recent decline in the price of that drug, it appears that over 4,000,000 ounces of quinine are consumed throughout the world every year.

The speculation in quinine is the chief feature of the drug trade at present. For some time past prices have ruled very low. Early in October the price was $2.10 and $2.20, and from this it declined by $1.70 and $1.80. Prior to 1879 the price ranged from $1.50 to $7, the latter price ruling during the war. In 1879 the duty on quinine, twenty per cent, *ad valorem*, was abolished, but, contrary to expectation, the price advanced from $3 to $4.75. This was explained by some as an act of retaliation on the part of American manufacturers, who, stripped of their monopoly, combined to put up the price to show that the removal of the duty did not benefit the consumer. Others attributed the advance to the unusual demand created at that time by the great yellow fever epidemic.

The cause of the decline from $2.20 to $1.80 for American and from $2.10 to $1.60 and $1.70 for German is not altogether clear, and in the trade is attributed to various causes, for the most part speculative.

There are only nineteen manufacturers of quinine in the United States and Europe. Of these, five are in the United

States—three in Philadelphia and two in New York. Most of the imported quinine comes from Germany, which has six out of the fourteen European manufacturers. Formerly a Philadelphia firm were the largest manufacturers in the world; now that distinction is held by Boehinger, of Milan, Italy, whose annual output is estimated at 1,200,000 ounces, or over a fourth of the world's consumption. Prior to 1879 the consumption in the United States was supplied chiefly by the home manufacturers and the foreign importation was very small.

American manufacture of quinine has greatly declined since the duty was removed. The primary cause of the decline in the price of quinine is traced to the discovery, in 1879, of enormous quantities of cinchona bark in the Capura district of the United States of Colombia. This discovery swelled the importations so greatly that 45,000 more packages were received in the London market in 1881 than in 1880. The enormous yield of the Capura district caused a decline in price from $3 per ounce to $1.47½. A powerful syndicate was then formed by a London merchant named Meyer, and large quantities of the Capura bark fell into his hands at about $1.50 per ounce. The syndicate sold 40,000 bales of the bark till last August, when it sold 30,000 bales at an advance of ten per cent. to Boehinger, of Milan. The price then advanced twenty per cent. to manufacturers. An endeavor was made to form a combination among the Continental manufacturers to force prices up, in the expectation that there would be large orders from America, and that the Egyptian difficulties would cause a general European war. Some of the manufacturers were willing, but there was a hitch somewhere, and the attempt to combine fell through. The purchase by Boehinger of so large a quantity of bark at so low a price placed him in a position to control the market.

It is said that Boehinger has been able, through his large purchase of cheap bark, to place large quantities of quinine in the market at from $1.55 to $1.70, while other manufacturers could not sell for less than $1.90. It is added that quinine cannot now be made for less than $2.12½ from bark at the price it now brings in the London market.

The Capura district is now believed to be failing, and unless another area of cinchona trees is discovered, the systematic cultivation of the bark will become imperative; a beginning has already been made in the East Indies.

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HENRY DRAPER.

HENRY DRAPER died at his residence in New York city on the 20th of November last. He had entertained the National Academy of Sciences at dinner on the evening of the 15th, and went from the table to his bed with a severe attack of pleuritis. Hope alternated with fear until Sunday, when pericarditis developed, and, in spite of the best medical skill, he died about 4 o'clock on Monday morning.

Professor Draper's career has been an exceptionally brilliant one. He was born in Virginia in 1837, his distinguished father, John William Draper, being at the time Professor of Chemistry and Physiology in Hampden Sidney College. Though he attended in early life the primary and preparatory schools of the University of the City of New York (to which place his parents removed when he was only two years of age), and subsequently became an undergraduate student at the same University, his real education was received in his own home. The eminence of his father as a teacher, an author, a philosopher, and an investigator created an atmosphere of scientific culture about him of the highest tone. It could not but happen that Henry, breathing constantly such an atmosphere, should be permeated with its spirit and early devote himself to research as the highest attainable purpose in life.

At the age of twenty, and before taking his medical degree, he made his first research, which was afterward published as his graduating thesis. It was on the function of the spleen, and was illustrated with microphotographs of great excellence. This early study of photography led him to the discovery of the value of palladious chloride as an intensifier. From this time dates his interest in the photographic studies in which he afterward attained such eminence. Shortly after graduation he spent a year in Europe, and made a visit to Lord Rosse at Parsonstown, Ireland. Here he saw the great reflector so well known to science, and became very much interested in it, because of its photographic possibilities. Upon his return he set about constructing a metal speculum fifteen inches in diameter, which he completed in 1860. In 1861, owing to a suggestion made by Sir John Herschel to his father, he abandoned speculum metal and made several mirrors of silvered glass 15½ inches in diameter. The details of the construction and mounting of these mirrors were published as a monograph, in 1864, by the Smithsonian Institution.

With this instrument a great amount of astronomical photography was done, the piece of work best known being his photograph of the moon. In perfection of detail it was far in advance of any previous attempt. The original negatives, of which over 1,500 were taken, were about an inch and a quarter in diameter, and they bore enlargement to three feet, and in one case to fifty inches, with excellent results. In 1870 he finished a second and larger reflector. Its mirror was also of silvered glass, twenty-eight inches in diameter, and like the former one, was ground, polished, corrected, silvered, and mounted solely by himself. The first telescope had been mounted in the Newtonian form. The new one was equatorially mounted and at first of the Cassegrainian form; but subsequently he improved it by making the secondary mirror plane. In 1875 an achromatic refractor of twelve inches aperture, made by Alvan Clark & Sons, was placed upon the same axis. And in 1880 this was exchanged for a telescope of a little less aperture, but furnished with an extra lens as a photographic corrector. A five-inch finder completed this unrivaled phototelescopic battery. All these instruments were mounted in an observatory built on his father's grounds at Hastings-on-Hudson. At first it consisted of but a single dome, containing the 15½ inch reflector; but subsequently a second and larger dome was added, and also the rooms needed for the transit instrument and chronograph, the photographic laboratory and the workshop. Though a wooden building of but one story, unpretending in appearance, its internal arrangements were admirable, and its facilities for astronomical photography entirely unsurpassed.

The work at the observatory was done chiefly during the summer months; Dr. Draper residing then at his country place at Dobbs Ferry, two miles distant. In the winter, he carried on investigations at his house in New York, those being selected for the purpose which did not require a telescope. At first, two rooms in the third story were devoted to these researches. But in 1880 he built a special physical laboratory as the third story of his stable in the rear of his house, this laboratory being connected with the house by a covered way. The equipment of this laboratory was superb. A siderostat by Alvan Clark & Sons, placed upon the roof, furnished abundant sunlight, directed to any part of the room by a secondary mirror. An Otto gas-engine of four-horse power gave motion to three dynamo-machines for the production of electric currents. One of these was a Gramme machine, wound double, and which, by an ingenious modification of his own, could be made to give a continuous or alternating current at will. The second was an Edison machine, used mainly to light the laboratory by means of incandescent lamps. The third was a Maxim machine used for producing arc lights, and also to feed the field of the Gramme machine. For the production of the electric spark, an induction coil of the largest size was employed, made by Ruhmkorff. Used with the direct current it gave 15-inch sparks readily, though the safety points were usually set at 10 or 12 inches to avoid perforation. With the Gramme direct current this coil yielded 1,000 ten-inch sparks per minute. With the alternating current, the spark, though silent and only one-quarter as long, was of much greater volume; so that when heavily condensed, the discharge was like the rattle of musketry. The optical and photographic appliances were of the finest. Complete spectroscopes and cameras were there, as well as the lenses, prisms, and gratings, of various materials and of the best workmanship, needed to extemporize those in research. A lathe, file bench, and carpenter's bench, each with its full set of tools, completed the appointments of this beautifully finished room.

With these facilities at his command, the original work which Dr. Draper did was of an exceedingly high order. Upon the completion of his large reflector, he applied it at once to the photographic reproduction of stellar spectra; and in 1872 he obtained a photograph of the spectrum of α Lyræ (Vega) showing dark lines; a result then unique in science. Continuing his labors he obtained more than a hundred stellar spectra of great excellence; latterly, and especially when he used the photographically corrected refractor, taking upon the same plate the spectrum of Venus, Jupiter, or the moon, for reference. In 1873, he published the finest photograph of the diffraction spectrum ever made. It included upon a single plate the region from wave-length 4,350, below G, to wave-length 3,440, near O. A steel plate from this photograph was introduced by Secchi into his great work on the sun, and in 1880 a lithograph of it was published in the *Proceedings* of the British Association as the most suitable reproduction extant for determining the wave-length of the fixed lines. The spectrum was obtained with a Rutherfurd grating of 6,481 lines to the inch, and in the photolithograph a portion of Angström's drawing is reproduced for comparison with it. In 1876 he succeeded, in face of great difficulties, in photographing the solar spectrum and the spectrum of an incandescent gas upon the same plate with their edges in contact; thus admitting of accurate comparison between the lines. He then noticed that, while the lines of the iron and aluminum used as electrodes coincided exactly with their proper dark solar lines, the lines of oxygen corresponded to bright solar lines. He was led to conclude, therefore, not only that oxygen actually existed in the sun, but that it existed there under conditions, probably of temperature, which caused it to radiate more light than the surrounding solar masses. At the same time, therefore, that he announced his discovery of oxygen in the sun, he proposed an important modification in the theory of the solar constitution. These conclusions were so radical that he deemed no labor too great which should strengthen them. He continued his researches in this direction, and early in 1879 produced a photograph of marvelous excellence on a much larger scale, which showed the coincidences, especially of groups, so accurately as to leave no longer any doubt upon the subject. He was anxious, however, to obtain conditions which should make the lines of oxygen sharper; and had made special preparation for the accomplishment of this result during the present winter.

While using the gelatino-bromide dry process in stellar spectrum photography, Dr. Draper conceived that the great sensitiveness of these plates might enable him to secure a photograph of a nebula, and so to obtain an accurate record of its present condition with a view to future comparisons. On September 30, 1880, he obtained, after an exposure of 57 minutes, a photograph of the great nebula of Orion, which was sufficiently perfect to enlarge. In order to get this much fainter nebula, the plate had, of course, to be overexposed for the stars. On the 11th of March, 1881, a second enlarged photograph was published, much more full in its details, the exposure being 104 minutes. And finally, on the 14th of March, 1882, he succeeded after an exposure of 137 minutes, in securing a photograph, wonderful in its detail, showing stars of the 14·7 magnitude on Pogson's scale, invisible to the eye, and giving the faint out-lying regions of the nebula with absolute perfection. This result must be regarded as the greatest triumph which astronomical photography has yet achieved. Besides these more difficult photographs, Dr. Draper obtained some excellent ones of the spectrum of the nebula. These are chiefly interesting because, besides the general bright line spectra characteristic of this nebula, they show in several places traces of continuous spectra, suggesting condensation.

Professor Draper's pre-eminence in celestial photography led to his selection in 1874, by the Transit of Venus Commission of the United States, as the Director of the Photographic Department. During the spring of that year, he spent three months in Washington engaged in devising improved methods, in testing instruments and materials, and in instructing those who were to use these methods how to obtain the best results with them. Although he did not accompany any of the expeditions, yet so conspicuous were his services that, upon recommendation of the Commission, Congress ordered a special gold medal to be struck in his honor at the Philadelphia Mint. This medal is 46 millimeters in diameter and has upon the obverse the representation of a siderostat in relief, with the motto: "Famam extendere factis hoc virtutis opus." On the reverse is inscribed the words: "Veneris in sole spectandæ curatores R. P. F. S. Henrico Draper, M.D., Dec. VIII, MDCCCLXXIV;" with the motto: "Decori decus addit avito."

In 1878, Professor Draper organized a party of five persons to observe the solar eclipse of July 29th. The station which he selected for observation was Rawlins, in Wyoming, on the line of the Union Pacific Railroad. The expedition proved an entire success, Professor Draper himself securing an excellent photograph of the corona and also one of its diffraction spectrum, which appeared continuous. Others of the party detected heat in the corona, and also faint dark lines in its spectrum. In 1880, Dr. Draper published an account of a photograph he had obtained of the spectrum of Jupiter, which appeared to him to afford evidence that this planet furnishes intrinsic light. The exposure required to get the spectrum was fifty minutes, that of the moon on the same plate being obtained in ten. In June, 1881, he photographed both the comet and its spectrum, using a slit and two prisms for this latter purpose. Three photographs were taken with exposures of 180, 196, and 228 minutes respectively, each having a comparison spectrum upon it.

Besides that spent in scientific work, Dr. Draper's time was largely occupied with his duties as instructor. In 1859 he was appointed on the medical staff of Bellevue Hospital, and served eighteen months. In 1860 he was elected Professor of Physiology in the Academic department of the University of the City of New York; a position which he held until the past year. In 1866 he was elected to the chair of Physiology in the Medical Department of the University and made Dean of the faculty. He managed the affairs of the college with signal ability and, by a liberal use of his own private means, brought it successfully out of the trying position in which it was placed by the destruction by fire of its building in Fourteenth Street. He severed his connection with the Medical School in 1873. For several years he had added Analytical Chemistry to the branches he taught in the Academic Department. Upon the death of his father in January, 1882, he was elected to succeed him as Professor of Chemistry, and gave the instruction in both chairs until the close of the collegiate year, when he resigned his connection with the University entirely.

Still a third portion of Professor Draper's time, and this no inconsiderable portion, has been given during the past ten years to the management of the large business interests in his hands. In 1867 he had married the daughter of Courtlandt Palmer, Esq., and upon his death in 1874, Dr. Draper was elected managing trustee of an immense estate, and was obliged to devote himself energetically to the work of reducing it to a solid investment basis. His success here has been as signal as in the work of scientific research and of instruction.

In 1861 Dr. Draper was appointed Surgeon of the Twelfth New York Regiment and served as such with distinction. In 1876 he was appointed a Judge in the Photographic Section of the Centennial Exhibition. In 1877 he was elected a member of the National Academy of Sciences and a member of the American Philosophical Society. In 1879 he received the election of Fellow of the American Association for the Advancement of Science. He was made a member of the American Academy of Arts and Sciences in 1881, and of the Astronomische Gesellschaft in 1875. In 1882 he received almost simultaneously the degree of LL.D. from his *Alma Mater* and from the University of Wisconsin.

Professor Draper's abilities were many-sided. In science, he was eminent in astronomy, in physics, in chemistry, and in physiology. He was exceedingly able as a mechanician, as the telescopes in his observatory with their wonderfully accurate mountings can testify. As a teacher he was clear, precise, and considerate. As a business man he is said to have had no superior in the city of New York. In social life he was brilliant, entertaining, companionable. He made life-long friends, often at the first contact, by the suavity of his manner and the charm of his presence. To get rest from the severe labors of the year and to fortify his constitution for the winter's strain, it had been his custom for eight years to join his friends, Generals Marcy and Whipple of the U. S. army, for a month's hunt in the Rocky Mountains during September. These expeditions he enjoyed greatly. He was an enthusiastic sportsman and a capital shot: and he entered upon the hunt with as much relish as he took a photograph. It was while out on such an expedition in 1877 that he made the important observations upon the suitableness of the air of that region for astronomical investigations. In 1882, the party was absent two months, traveling on horseback from the Union Pacific to the Northern Pacific Railroad; and when he was above timber line he was exposed to a severe and intensely cold snow storm.

Professor Draper had not published very extensively at the time of his death. This is the more remarkable as he was fond of writing, a trait no doubt inherited from his father. A list of publications is appended to this notice. There can be little room to doubt that he had not been cut down so abruptly in the midst of a host of projected investigations, the world would have been enriched during the next twenty years with a wealth of discovery almost unparalleled.

Looked at from any stand-point, the death of such a man as Henry Draper cannot be viewed but as a calamity. At the age of 45 years, with very many years of good work apparently before him, with the experience and learning of the twenty years past added to a rich and varied natural endowment, giving promise of a scientific career of exceptional brilliance, it is no wonder that the world of science mourns his departure. Moreover he seemed to be just ready for his life work. He had completed the building and equipment of his observatory and laboratory, and had arranged everything ready for experiment. He had given up his professorship, and was reducing his business cares in order to get more time for research. He had stored his mind for years with precious facts which he hoped now to utilize in the highest investigations. Finally he had a most devoted wife who always acted as his assistant, and to whose skilled hand and thoroughly trained eye he has attributed much of the success he had already attained. Such men it is that the world is made poorer by losing. They are all too few, and when one drops from the ranks of honest and earnest workers, the gap is never completely filled.

G. F. B.

LIST OF HENRY DRAPER'S ORIGINAL PAPERS.

1. On the Changes of Blood Cells in the Spleen. *New York Journal of Medicine*, III, v, 182-189, Sept., 1858.
2. On a new Method of Darkening Collodion Negatives. *Am. J. Phot.*, II, i, 374-376, May, 1859.
3. On a Reflecting Telescope for Celestial Photography. *Rep. Brit. Assoc.*, 1860, II, 63-64.
4. On the Photographic use of a Silvered Glass Telescope. *Phil. Mag.*, IV, xxviii, 249-255, 1864.
5. On a Silvered Glass Telescope and on Celestial Photography in America. *Quar. J. Sci.*, i, 381-387, Apr. 1864.
6. On the Construction of a Silvered Glass Telescope 15½ inches in aperture, and its use in Celestial Photography. *Smithsonian Contr.*, XIV, Part II, July, 1864.
7. Petroleum; its Importance, its History, boring, refining. *Quar. J. Sci.*, ii, 49-59, 1865. *Dingler's Polyt. J.*, clxxviii, 107-117.
8. American Contributions to Spectrum Analysis. *Quar. J. Sci.*, ii, 395-401, 1865.
9. A Text-book on Chemistry. New York, 1866.
10. Report on the Chemical and Physical Facts collected from the Deep Sea Researches made during the voyage of the Schoolship Mercury. *Rep. Comm. Pub. Charities*, New York, 1871.
11. On Diffraction Spectrum Photography. *Am. J. Sci.*

III, vi. 401–409, Dec. 1873. *Phil. Mag.*, IV, xlvi, 417–425. *Ann. Phys. Chem.* cli, 337–350, 1874.

12. Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from 4,500 to 11,000 feet in Utah and Wyoming Territories and Colorado. *Am. J. Sci.*, III, xiii, 89–95, Feb. 1877.

13. Photographs of the Spectra of Venus and α Lyræ. *Am. J. Sci.*, III, xiii, 95, Feb. 1877. *Phil. Mag.*, V, iii, 238.

14. Discovery of Oxygen in the Sun by Photography, and a new Theory on the Solar Spectrum. *Proc. Am. Phil. Soc.*, July, 1877, 74–80. *Am. J. Sci.*, III, xiv, 89–96, 1877.

15. Observations on the Total Eclipse of the Sun of July 29, 1878. *Am. J. Sci.*, III, xvi, 227–230, 1878. *Phil. Mag.*, V, vii. 318–320.

16. On the coincidence of the Bright Lines of the Oxygen Spectrum with the Bright Lines of the Solar Spectrum. *Am. J. Sci.*, III, xviii, 262–277, 1879. *Monthly Not. Astr. Soc.*, xxxix, No. 8.

17. On Photographing the Spectra of the Stars and Planets. *Am. J. Sci.*, III, xviii, 419–425, Dec., 1879.

18 On a Photograph of Jupiter's Spectrum showing evidence of Intrinsic Light from that Planet. *Am. J. Sci.*, III, xx, 118–121, 1880. *Monthly Not. Astr. Soc.*, xl, 433–436.

19. On Photographs of the Nebula in Orion. *Am. J. Sci.*, III, xx, 433, 1880. *Phil. Mag.*, V, x, 388. *C. R.*, xci, 688; xcii, 173, 964.

20. On Photographs of the Spectrum of the Comet of June, 1881. *Am. J. Sci.*, III, xxii, 134, 1881.

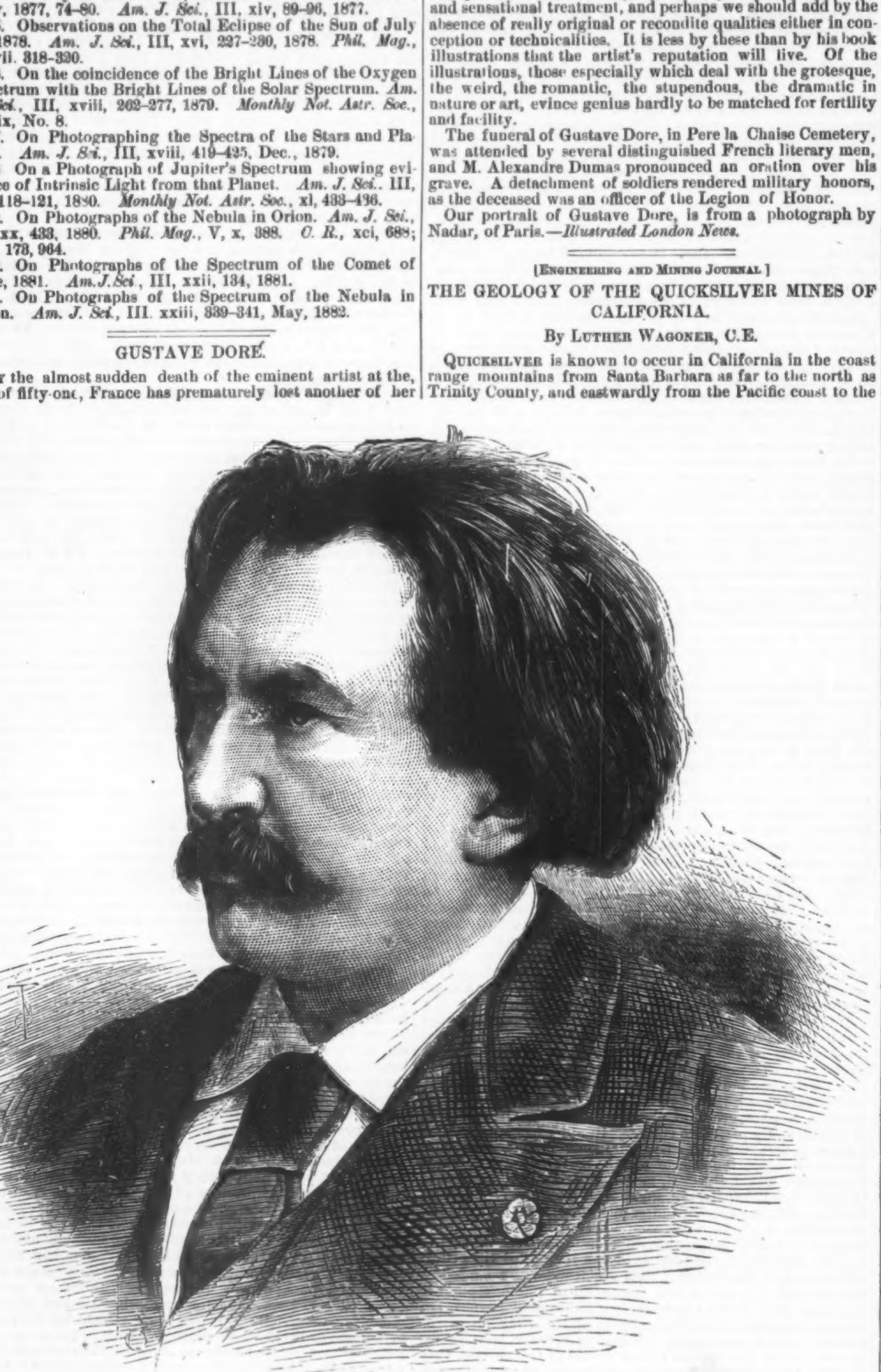
21. On Photographs of the Spectrum of the Nebula in Orion. *Am. J. Sci.*, III. xxiii, 339–341, May, 1882.

GUSTAVE DORÉ.

By the almost sudden death of the eminent artist at the age of fifty-one, France has prematurely lost another of her most gifted sons. Gustave Doré was born at Strasburg in January, 1832. He went to Paris in 1845 to complete his studies at the Lycee Charlemagne. When only sixteen years of age he contributed humorous sketches to the *Journal pour Rire.* Many of his early drawings, by the way, are caricatures of that English people toward whom he afterward became so friendly, and among whom he has found his most generous admirers. Yet curious misapprehensions, and a want of observation, not uncommon in the French, seemed always to characterize his representations of everything English. His "London," for instance, is perhaps his weakest performance; and even his illustrations of Tennyson and other English authors are wanting in true sympathy. The works he contributed to the exhibitions at the Salon from 1849 to 1853 attracted some attention, but it was not till 1857 that he obtained an Honorable Mention for a landscape and a painting of the "Battle of Inkerman." He continued throughout his career to exhibit at the Salon landscapes and figure pictures, nearly always of very ambitious character; but he never won among the artists and more severely critical public of his own country the estimation as a painter that he has largely obtained in this. Meanwhile, however, his reputation as an illustrator increased rapidly on both sides of the Channel, particularly with his illustrations of Rabelais, the "Wandering Jew," the "Contes Drolatiques" of Balzac, the "Contes de Perrault," and other works. And subsequently he achieved world-wide renown by his illustrations of Dante's "Divina Commedia," "Don Quixote," "Orlando Furioso," the Bible, and other works. He contemplated the illustration of Shakespeare, but was not spared to complete the gigantic task. As a sculptor, also, Dore evinced very considerable skill in the great Bacchanalian vase shown at the Paris Exhibition of 1878. The vast and crowded canvases at Dore Gallery, in Bond-street, are too familiar to require enumeration or description. The popularity of these works and the engravings from them with the British public, and particularly the religious section of that public, is explained by their subjects, their grandiose and sensational treatment, and perhaps we should add by the absence of really original or recondite qualities either in conception or technicalities. It is less by these than by his book illustrations that the artist's reputation will live. Of the illustrations, those especially which deal with the grotesque, the weird, the romantic, the stupendous, the dramatic in nature or art, evince genius hardly to be matched for fertility and facility.

The funeral of Gustave Dore, in Pere la Chaise Cemetery, was attended by several distinguished French literary men, and M. Alexandre Dumas pronounced an oration over his grave. A detachment of soldiers rendered military honors, as the deceased was an officer of the Legion of Honor.

Our portrait of Gustave Dore, is from a photograph by Nadar, of Paris.—*Illustrated London News.*



GUSTAVE DORÉ. [From a Photograph.]

[ENGINEERING AND MINING JOURNAL.]

THE GEOLOGY OF THE QUICKSILVER MINES OF CALIFORNIA.

By LUTHER WAGONER, C.E.

QUICKSILVER is known to occur in California in the coast range mountains from Santa Barbara as far to the north as Trinity County, and eastwardly from the Pacific coast to the valleys of the San Joaquin and Sacramento. South of the Bay of San Francisco, the deposits occur in the coast range of mountains and in the Mount Diablo range upon both slopes of the respective mountains; and to the north of the Bay of San Francisco, it is found in the coast range proper, in the range of hills between Russian River and Napa Valley, upon the eastern slope of the Mount Helena chain, and at the contact of the Cretaceous and Tertiary at the eastern line of Napa County. The elevations of the outcrops above the level of the sea vary from 500 to 4,000 feet and are known to extend downward below sea level to a depth of from 200 to 300 feet (New Almaden and Guadalupe). The outcrop or the body of ore appears to be located at the point of inflection or contrary curvature that marks the transition from an anticlinal to a synclinal system, and its angle with the horizon is from 45 to 80 degrees, from 50 to 60 degrees being the more general dip. The strike of the ore-bearing formation is in general parallel to the coast or to the mountains in which it is found. The country rock is invariably stratified. No exception is known to this law of formation, as the deposit at the Sulphur Bank, Lake County, is a superficial crust of volcanic matter resting upon the stratified sandstones and schists which are cinnabariferous for a depth of 230 feet below the volcanic matter, as shown by the workings of the mine to that depth. Serpentine and its allied rocks accompany the deposits of cinnabar for its entire length, and associated with it are deposits of chromic iron which are irregular, but as constant as the cinnabar. The country rocks are largely sandstones and shales when in their unaltered condition, and are found in all stages, from the unaltered fossiliferous (Oceanic and Redington) to the highly metamorphosed (New Almaden and Great Western). The deposits of cinnabar are veins; for they have a regular hanging wall and foot wall, which in general are different, the latter being in most instances serpentine, and the hanging wall a sandstone or shale altered or unaltered. The gangue is usually from 50 to 300 feet thick, and is essentially different from its inclosing walls. Talcose and argillaceous schists and magnesian rocks comprise a large portion of the gangue and quartzite, jasper, and opal have a grand development in some of the mines.

The cinnabar does not impregnate the entire gangue, but lies in irregular bodies next to the hanging wall, or nearer to the hanging wall than to the foot wall, and the bodies are in general connected by threads or seams, and are of variable dimensions. The largest ore body observed was about 300 feet long, 80 feet high, and 30 feet thick. The tenor of the ore was about 25 per cent. of mercury, and portions reached as high as 70 per cent. The cinnabar is observed equally to impregnate the soft schistose rock and the porous sandstone when they lie in contact and in the most irregular manner. Associated with the gangue are sulphurets and oxides of iron, sulphur, bitumen, mineral oils, and various bituminous substances, aragotite, posepnite, etc., carbonic acid, sulphurous acid, carbureted and sulphureted hydrogen, and solfataric waters. Boracic acid and native gold are said to occur at the Sulphur Banks, the gold being inclosed in cinnabar, and minute particles of chromic iron are found in the ore from the Los Prietos at Santa Barbara.

In the San Carlos mine, near New Idria, the gangue is a brecciated jasper cemented with cinnabar; and at the Redington mine, the gangue is an opal much fissured, the cinnabar filling the fissures, and having long, thread-like appendages of ore hanging from the mass of ore; these are called "hangers" by the miners. The opal is separated into several veins or strata by bands of clay. Toward the eastern or hanging wall, a notable change takes place, the gangue being the usual soft schistose clay, and the ore bodies running parallel with the strata. They are devoid of hangers, but are connected with one another by a more or less complete thread or veinlet of cinnabar. The vein here appears to follow the contact between the serpentine foot wall and the sandstone unaltered fossiliferous hanging wall. This ore body, as seen in plan, appears to dip at 45 degrees or toward the center of the Blue Range, and its strike is warped around the point of the serpentine hill, thus creating an ore body having a warped surface. The heat is intense in certain parts of the old workings. In one place, where the gangue is highly charged with pyrites and the rock is dry, the temperature was found to be 125 degrees F., and an intense suffocating atmosphere of sulphurous acid, very irritating to the eyes and lungs, is met with. The temperature in some of these places would perhaps attain 150 degrees. Mineral oil occurs in considerable quantity, a barrel of forty gallons being collected in one drift. It was used for lubrication of the machinery. Oil more or less oxidized is observed in all mines of quicksilver on this coast, and in general is found as bitumen or a thick tar. At the Great Western, near Mount St. Helena, it occurs as a yellowish amber or greenish colored oil inclosed in lenticular or ovoidal capsules of quartzite, from one-sixteenth to one and one-half inches in diameter. The oil is tasteless and has the odor of burning rubber, and in the seams it is found of a tough, elastic nature, resembling thickened linseed oil. This is the substance known as posepnite, and it is analogous to paraffine, having the formula $C_{22}H_{38}O_4$.

In the Oceanic, New Idria, and Napa Consolidated mines, the sandstone, which is of a porous, open texture, having rounded grains and a light gray or yellowish color, has been completely removed in places, and chloritic and talcose schists of a dark olive green color, and generally quite soft, are found filling the place of the original rock. Occasionally the sandstone presents itself in thick masses; but more frequently it is interstratified with thin layers of what appears to have been silt or mud. The sandstone in some of these deposits has been fissured into small rectangular blocks, and the substitution of the clays for the sand has been carried on in joints and along the bedding, this giving rise to small spherical masses of sandstone inclosed in the clays, and retaining their original bedding, which is clearly shown when the fragments are large enough to inclose a thin band of the silt or mud spoken of. This and other allied phenomena are beautifully illustrated in the Napa Consolidated and Oceanic mines. In nearly all of the mines, certain lenticular bodies of sandstone, apparently unaltered, are met with, and at times they are of considerable magnitude, a thin casing of clay surrounding them as far as could be seen. It would be interesting to know if their present unaltered state is due to this envelope. From a careful examination of all the mines I am inclined to think that the vein proper was originally an argillaceous or arenaceous shale, having at times bands or strata of sandstone interstratified with it. This is seen clearly at the Oceanic, where the cañon presents a good section for a half mile each way from the mine. There, sandstones from one to twenty feet in thickness are seen interstratified with the shales, and fossils observed would indicate that its age is Tertiary. The New Idria mine and the San Carlos, which are back upon the eastern slope of the San Carlos peak, are quite dissimilar in their gangues, the former having the chloritic schists and dark talcose or serpentine clays associated with nearly all of the mines; while the latter has a gangue largely composed of brecciated jasper or sandstone, and cemented with cinnabar. The mine is located near the central axis of the mountain, and the inference drawn from its synclinal structure is, that metamorphism was effected before or contemporaneously with the upheaval of the strata, and that the mineralization was effected later. As the New Idria mine is located near by, we may reasonably infer that the formation of the ore deposits was synchronous; and as the latter mine presents many features in common with others, both north and south, it is not unreasonable to infer that all of the quicksilver deposits were formed after the upheaval of the coast range, and are not older than the Cretaceous, the most probable age being that of the Tertiary, as the Los Prietos and Oceanic are wholly within the latter, and to the north the Redington is found at the contact of the two epochs. The lode and country rock are in general free from vuggs; but one of considerable size was noticed (New Almaden) upon the side of an ore chamber. Its internal surface presented a drusy appearance. Vuggs are only found where the gangue or country rock is hard. A noticeable feature of the outcrop of the mines is, that they are always harder than the country rock, and, wherever seen, are of a light brick-red color, and stand out in bold relief from the adjacent strata. Thus at the Great Western, the outcrop appears as a dike over one hundred feet wide, and having precipitous sides, in places seventy-five feet high,

The outcrop is a quartzite, jasper, or opal, or an argillaceous sand stone silicified, more or less silica being apparently the predominant element. All of the mines are free from faults, but the veins occasionally change their dip as much as 50 degrees, but in the main it is preserved. Thus, if a vein be dipping north 45 degrees, it may be found to change its course and dip south from 70 to 90 degrees; but soon it changes back to north. This is equally applicable to the strike; and as the exploitation is effected by levels driven along the hanging wall, it can be readily imagined how variable their course must be. If the hanging wall could be removed and disclose to our view the veins, we should see in general a more or less warped surface, studded with numerous wrinkles crossing each other. The ore bodies would be seen at various points, but connected more or less by smaller bodies, or threads of ore.

The constant occurrence of the ore at the contact of the hanging wall goes powerfully to support the argument that cinnabar is a deposit from an aqueous solution, which came from below under great pressure and temperature, and as it neared the surface, the reduction of temperature and pressure caused a corresponding deposition of cinnabar. It followed up the most porous or open channel, and hence is always in contact with the hanging wall. Where an abrupt flexure or change of dip has taken place, the ore is sometimes found on the foot wall side (Guadalupe), as would be expected if the waters had followed the shortest route. The fact of cinnabar occurring in veins or deposits generally at an angle of from 40 to 60 degrees with the horizon, coupled with the general geological features, would indicate that in most cases the deposit has occurred at the *point of contrary flexure*, or at the transition from synclinal to anticlinal. If this be correct, it affords some clew to the probable depth of the deposit, which must be a lenticular mass whose greatest development is at the point of inflection. An increasing dip will be attended with increased ore up to the point of reverse curvature; and a general decrease of dip or flattening of the vein will indicate the approach of the bottom limit of the ore. Sufficient data are not at command to warrant the assertion that the above is a law; but it certainly accords nearly with the facts.

To the geologist no region can present a better field for the study of metamorphic action, and doubtless if systematic work were undertaken at all the prominent mines in the district, it could not fail to throw a flood of light on much interesting but at present disconnected data.

THE ROMAN FORUM AT ARLES, FRANCE.

AT Arles there is so much to see, and that not only interesting to the ordinary traveler, but also in the highest degree to the archæologist and the antiquary. Thus, at one side of the Place du Forum are the remains of the Roman Forum. A little way beyond is the Hotel de Ville, and close to this the Cathedral of St. Trophime, with its beautiful doorway, one of the most perfect works of the twelfth century. The cloisters are also very perfect and interesting. From this church the small Boulevard is soon reached, and here, in the evening, the people fully enjoy a saunter and gossip—I cannot say after the fatigues of the day, for in Arles no one ever seems in a hurry, or to have anything to do. To the right is the Roman Cemetery, with a very quaint chapel, and a number of sarcophagi and stone coffins. Nearly opposite, on the left of the Boulevard, are public gardens, with a notice which might well be used in like places in England, instead of the uncivil, impertinent ones so often seen: "Les Jardins Public ayant ete crees pour l'agrement de tous, sont mis sous la protection de tous les citoyens." Through these gardens is a path to the beautiful remains of the Roman Theater, where the marble statue of Venus, now in Louvre, was found not many years ago. It then passes a most curious old church, and on to the Amphitheater. This is very perfect to a certain height all round, like that at Pompeii, though much more resembling the one at Rome, without, however, being anything like so grand and solemn. The Amphitheater at Arles is the largest built by the Romans out of Italy, and dates from the time of Caligula. It is 459 feet by 341 feet, has five corridors, and contained about 26,000 spectators. From one of the towers there is a magnificent view of the old town below, of the larger and lesser Rhone winding through the plain, and the distant mountains, with their grim, gray old towns and ruins discoverable one after the other on ledge and rock. The drives round Arles are beautiful, especially one to the ruined Abbey of Mont Majeur—the home of St. Trophime before he became Bishop of Arles.—*London Graphic.*

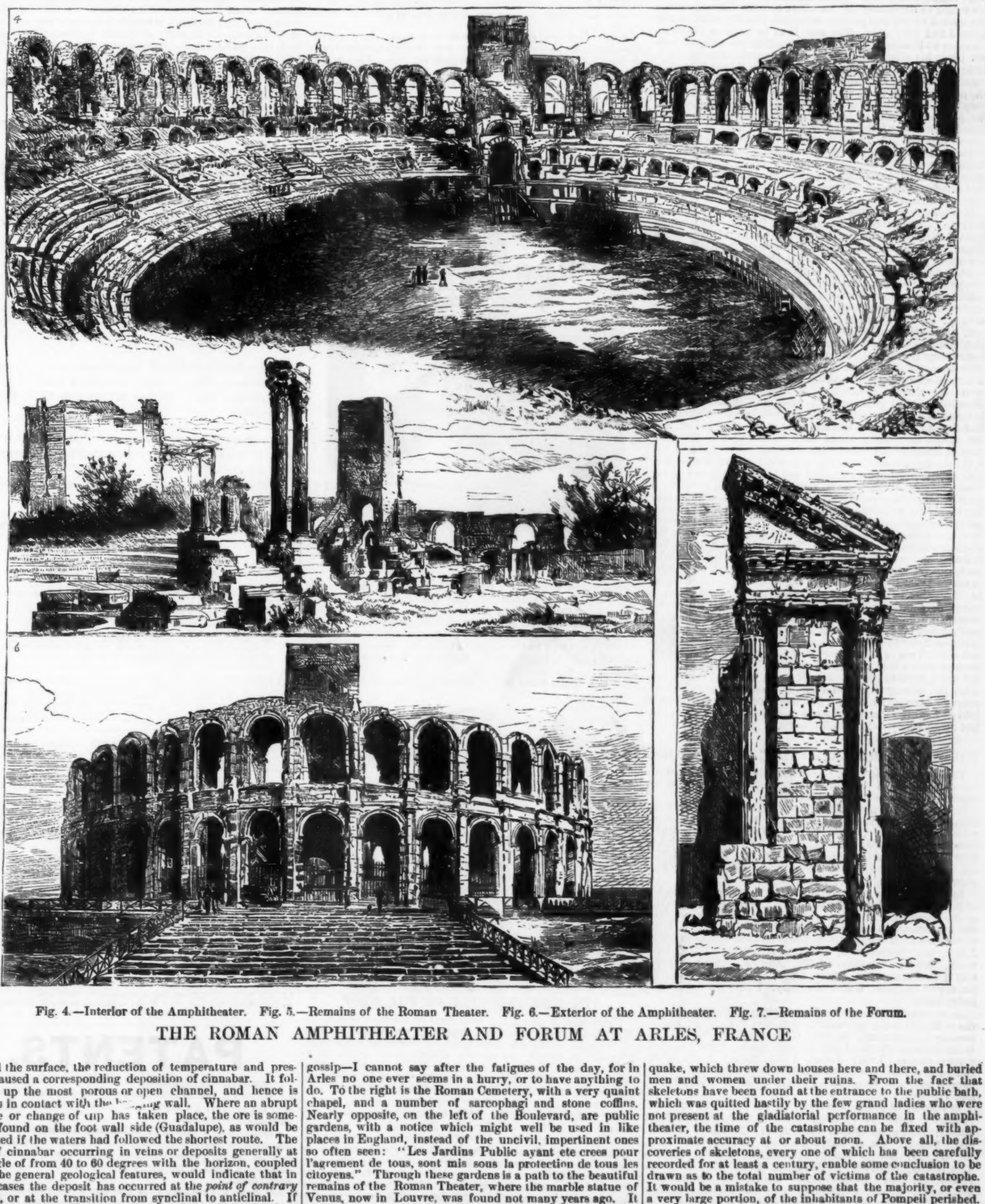


Fig. 4.—Interior of the Amphitheater. Fig. 5.—Remains of the Roman Theater. Fig. 6.—Exterior of the Amphitheater. Fig. 7.—Remains of the Forum.

THE ROMAN AMPHITHEATER AND FORUM AT ARLES, FRANCE

THE VICTIMS OF POMPEII.

THE work of exploration which has been steadily going on in Pompeii for over a century from the day when excavations first began on the site of what was then vaguely called "La Civita," in 1748, has led to other than purely archæological results. It has enabled a fairly accurate notion to be formed of the nature and extent of the catastrophe. We know, for instance, that the lava stream did not reach Pompeii, and that the city was not destroyed by fire. We know also that the eruption was accompanied by one or more shocks of earthquake, which threw down houses here and there, and buried men and women under their ruins. From the fact that skeletons have been found at the entrance to the public bath, which was quitted hastily by the few grand ladies who were not present at the gladiatorial performance in the amphitheater, the time of the catastrophe can be fixed with approximate accuracy at or about noon. Above all, the discoveries of skeletons, every one of which has been carefully recorded for at least a century, enable some conclusion to be drawn as to the total number of victims of the catastrophe. It would be a mistake to suppose that the majority, or even a very large portion, of the inhabitants of Pompeii perished. The effects of the ashen shower were not instantaneous, and every one who could get away from the city on the first alarm probably saved his life. The bulk of the people were in the amphitheater, which was situated near one of the city gates on the side remote from Vesuvius, and there was nothing to hinder every one in the great audience from getting away in time. Those who perished were those who delib-

erately put off their flight to save wife and child, or still more often, valuables.

Of such victims 450 have been already found. From the year when the excavations began, in 1748, to the year 1826, the total number of human remains discovered was 160; from 1827 to 1845 it was 63; from 1846 to 1860 it was 60; from 1861 to 1872 it was 87; and from 1873 to 1881 about 100. But it is to be remembered that only two-fifths of the buried surface has been brought to light. On the whole, there appears good reason for putting the total number of human beings who perished in the eruption at least as high as 1,100. To these should be added the skeletons of three dogs, seven horses, eleven hens, two tortoises; fifteen pigs, ten oxen, and the bones of fifteen other animals. The remains of one of these dogs were found in the porch of the "House of Orpheus," and the cast which Signor Fiorelli has taken brings before us with a painful vividness one of the minor tragedies of that awful day. The poor beast was chained at his post, and in the general panic and confusion no one remembered to let him loose. The chain lay by the remains when they were found, and it was evident that the creature had strained his tether to the utmost in the effort to keep himself above the masses of ash and pumice stone that rapidly accumulated around and over him. The cast is to be seen in the little museum at Pompeii. The dog lies half on his side, half on his back, his slender head and open muzzle gasping for a little air, buried between the hind legs, which have been convulsively brought forward in the last agony of death. But the process which has been so successful in reproducing the very form and likeness of this creature as he lived and died has produced results no less extraordinary in the case of the human victims of the catastrophe. The idea of pouring plaster of Paris in a liquid state into the moulds left by the bodies in the soft ash did not occur to any one till it suddenly flashed across Fiorelli about twenty years ago. Of the remains of the 180 human beings discovered in Pompeii in the first hundred years of the excavations there is consequently only a written record.

It is only from the *The Journal of Excavations* for the year 1831 that we know of the touching and famous sight which greeted the eyes of the first discoverers of the "House of the Faun." On the floor of the banqueting hall lay the body of a woman, probably the mistress of the house, with her jewels scattered where she had thrown them in despair of rescue or escape. The roof had been crushed in by the weight of falling ash and pumice stone, and the hands of the dying women were upstretched in a vain effort to keep off the impending weight. Parts of the body and clothing could still be made out, and a drawing could be made of one charming foot. But such records are lifeless and tame indeed beside the extraordinary portrait statues which are now to be seen in the little museum at Pompeii. There are nine of these, or were a very short time since, and to see them is like seeing the men and women themselves of eighteen centuries ago. Fiorelli's method is as simple as possible. A small opening is made, the plaster is delicately poured in, and when it has had time to harden, the surface crust of ash is peeled off, and the man or woman comes back to life again. The details of clothing and feature have all left their mark on the soft ash, and are all faithfully preserved in the plaster cast. The results achieved by Fiorelli are striking and complete. Take the cast of the elderly slave, for instance, probably a man of some sixty years old, who appears to have been taking his siesta when the eruption began, and to have been painlessly asphyxiated in his sleep. He lies on his right side, the knees a little bent, the left leg drawn up, and the cheek resting on the right hand. The course, strongly marked features and peaceful expression of the sleeper have all been perfectly preserved. A hardly less easy death must have been the lot of the four persons found lying on their backs in the street. Three of these were men, one of them a negro of the most pronounced type. The fourth was a woman of unusual stature, whose time for becoming a mother was evidently not far off. The three persons found lying on their faces do not appear to have found quite so quick a death. Two of them are women. One of these, an elderly woman with a thin figure, lies by herself, her face buried in her arms, as if to protect herself from the fatal rain. The other lies side by side with a man in whose company she appears to have taken flight. She has covered her face with a fold of her dress, and the hands are tight clinched in the last death agony.—*Pall Mall Gazette.*

THE WORLD AS RELATED TO THE POST-OFFICE.

THE report of the U. S. Superintendent of Foreign Mails for the last fiscal year presents the following comparative statistics of the world's postal business:

In number of post-offices the United States ranks first, with 46,893 offices; then Great Britain, with 14,549; Germany, with 9,460; France, 5,942; Japan 4,665; Russia, 4,458; British India, 4,409; Austria, 4,025; Italy, 3,328; Switzerland, 2,852; Spain, 2,642; Hungary, 2,301; Sweden, 1,785; the Netherlands, 1,316; Norway, 924; Mexico, 897; Belgium, 792; Portugal, 755; Denmark, 560.

In respect of the relative proportion between the number of post-offices and that of population, the principal countries of the union rank as follows: Switzerland has an average of 993 inhabitants to each post-office; the United States, 1,167 to each office; Norway, 2,078; Great Britain, 2,372; Sweden, 2,565; the Netherlands, 3,085; Luxemburg, 3,175; Denmark, 3,537; Germany, 4,778; Austria, 5,498; France, 6,211; Portugal, 6,285; Spain, 6,333; the Argentine Republic, 6,400; Belgium, 6,991; Hungary, 7,258; Japan, 7,701; Italy, 8,515.

In number of letter-boxes for reception of correspondence, the principal countries rank as follows: France, 57,960 letter-boxes; Germany, 57,782; Great Britain, 27,782; the United States, 18,460; Italy, 11,559; Spain, 9,406; Austria, 8,018; Russia, 7,957; Japan, 6,955; British India, 6,192; Belgium, 5,456; Switzerland, 5,270; Denmark, 3,382; Hungary, 3,203; the Netherlands, 3,047; Sweden, 2,700; Portugal, 1,303.

In number of letters conveyed in the mails the principal countries rank as follows: Great Britain, 1,176,423,600 letters; the United States, 847,830,029; Germany, 522,689,800; France, 488,462,763; Austria, 174,990,000; Italy, 151,471,018; British India, 118,072,430; Russia, 92,451,476; Spain, 66,525,891; Hungary, 64,647,572; Belgium, 61,209,200; the Netherlands, 48,070,589; Switzerland, 45,739,594; Japan, 36,898,795; Sweden, 27,130,454; Denmark, 22,011,999; Portugal, 14,124,919.

In number of postal cards conveyed in the mails the principal countries rank as follows: The United States, 275,824,224 postal cards; Germany, 185,135,100; Great Britain, 122,884,000; Austria, 36,026,000; France, 27,540,065; Japan, 19,884,451; Italy, 19,714,710; Belgium, 14,720,842; the Netherlands, 13,775,947; Hungary, 12,965,458; British India, 7,471,984; Switzerland, 6,649,297; Russia, 4,682,544; Sweden, 1,250,081; Roumania, 685,802; Portugal, 252,751; Norway, 209,014; Denmark, 178,128; Spain, 161,986; Luxemburg, 155,883.

In respect to the number of letters and postal cards per each inhabitant, the principal countries rank as follows: Great Britain, 37·6 to each inhabitant; the United States, 22·8; Switzerland, 22·4; the Netherlands, 17·1; Belgium, 16·2; Germany, 15·6; France, 14·9; Denmark, 12·6; Luxemburg, 11·7; Austria, 11·1; Sweden, 6·9; Italy, 6·6; Norway, 5·7; Spain, 4·1; Portugal, 3·3; Greece, 1·7; Japan, 1·6; Roumania, 1·2; Russia, 1·1.

In number of newspapers conveyed in domestic mails the principal countries rank as follows: The United States, 730,269,063 newspapers; Germany, 420,944,000; France, 285,691,654; Great Britain, 133,796,100; Russia, 83,233,945; Italy, 81,060,778; Austria, 75,282,900; Belgium, 64,680,000; Switzerland, 49,967,736; the Netherlands, 33,682,452; Hungary, 27,722,577; Denmark, 25,007,457; Sweden, 21,087,036; Japan, 17,596,758; British India, 11,251,021; Norway, 10,402,002; Argentine Republic, 7,500,000; Greece, 1,688,841.

THE DECAPITATED PACHA.

IT has often been said, that there is nothing new except what has been forgotten. This is true of the ingenious mechanical toy shown in the accompanying cut. The manufacturer who devised this scarcely suspected that it was in nearly every respect like the decapitated drinking horse described by Heron, of Alexandria.

This toy, which is styled the "Decapitated Pacha," consists of a painted tin bust, to which is hooked a small saber (Fig. 1), and which is so constructed that the saber may be

FIG. 1.—THE DECAPITATED PACHA.

passed clean through the neck without causing the head to separate from the shoulders. The mechanism that permits of obtaining so curious a result is extremely simple. The head is affixed to the axle of a three-toothed wheel, A B C (Fig. 2), the edges of whose divisions engage in a brass guide which is adapted to the upper part of the shoulders of the toy, and which consequently forms the lower part of the neck.

In Fig. 2, the saber in its different positions is represented

FIG. 2.—EXPLANATION OF THE MECHANISM.

by an arrow. On first entering the neck it causes the tooth, C, to slide, as shown in No. 1, of Fig. 2. At the moment this tooth leaves the guide, the following tooth, B, engages therein (Fig. 2, No. 2); and, when the blade leaves the neck on the other side in pushing before it the tooth, C B, will have taken C's former position, as shown in No. 3. As long as the mechanism just described is not known, the illusion is complete, and it is difficult to understand how the head, although apparently cut off each time, manages to adhere to the bust.—*La Nature.*

THE ZINC INDUSTRY OF THE WEST.

HITHERTO, it seems, the treatment of the zinc ores of the West has not ben profitable generally, or except possibly at two large works, one at St. Louis and the other at La Salle, Illinois. However, during the present year, at the latter works a most important discovery has been made—very important in industrial consequences; that is to say, a process for extracting a first-class article of sulphuric acid from the escaping fumes of the zinc furnaces, adding greatly to the profits of the works. As a direct consequence of this discovery, the firm of Marsh & Harwood, of Cleveland, manufacturing chemists, already having a branch of their industry at St. Louis, are said to be about embarking very largely at the latter point in the business of treating zinc ores, of which there is so abounding a supply in southwest Missouri and southeastern Kansas. Already there are three smelting works, we hear, in St. Louis with a daily average output of from 25,000 to 30,000 pounds of spelter, the chief market for which is in Massachusetts and Pennsylvania. At present all the spelter produced in Kansas and Missouri comes to St. Louis for distribution. The only zinc rolling mill in the West is at La Salle, Illinois. Part of the ore used in this establishment is obtained in northwestern Illinois and southwestern Wisconsin, and part comes from Kansas and Missouri. Pittsburg, Kansas, has three smelting works. The coal used in them, found near by, has to be coked to free it from sulphur. The largest of these works produces about eight tons of spelter daily, and is building new furnaces which will increase its capacity to ten tons.

Rich Hill, the infant mining city in Bates County, Missouri, has smelting works in operation, and there is a probability that the Southwestern Zinc Smelting Company will build a rolling mill there, to cost $100,000. In the manufacture of zinc, fire clay is of very material importance for the supply of retorts and other appliances, and all the Western smelting works draw their supply from Cheltenham, adjoining St. Louis.—*Mining Record.*

A BALLOON EXHIBITION IN FRANCE.

IT is expected that the French Government will take in hand the celebration of the centenary of the discovery of balloons. The two committees which had been formed by several aeronautical societies have been amalgamated, and M. Gaston Tissandier has been appointed president. The scheme of an international exhibition for balloons and instruments used in aerial investigations has been adopted by M. Herrisson, the Minister of Public Works, and will be carried into effect by M. Armengaud Jeane, the well-known civil engineer.

A CATALOGUE containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

TABLE OF CONTENTS.